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THESIS

STANDARDIZATION OF HULL, MECHANICAL, AND ELECTRICAL EQUIPMENT (H,M&E) INVENTORY

by

John Charles Corbett

September 1987

Thesis Advisor: David R. Whipple

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CLASSIFIED
URITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited
DECLASSIFICATION/DOWNGRADING SCHEDULE	
ERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
NAME OF PERFORMING ORGANIZATION val Postgraduate School	6b OFFICE SYMBOL (If applicable) 54
7a NAME OF MONITORING ORGANIZATION Naval Postgraduate School	
DDRESS (City, State, and ZIP Code) nterey, California 93943-5000	7b ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000
AME OF FUNDING/SPONSORING RGANIZATION	8b OFFICE SYMBOL (If applicable)
9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
DDRESS (City, State, and ZIP Code)	10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO

TLE (Include Security Classification)
ANDARDIZATION OF HULL, MECHANICAL, AND ELECTRICAL EQUIPMENT (H,M&E) INVENTORY

ERSONAL AUTHOR(S)
rbett, John Charles

TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year Month Day)	15 PAGE COUNT
ster's Thesis	FROM _____ TO _____	1987 September	167

UPPLEMENTARY NOTATION

COSATI CODES		
ELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Inventory Standardization; Hull, Mechanical & Electrical; Standardization; Inventory; Non-Standard Inventory Cost Model

BSTRACT (Continue on reverse if necessary and identify by block number)

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STRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ OTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified

NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code)	22c OFFICE SYMBOL
fessor David R. Whipple	408 646-2754	54Wp

ORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

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Standardization of Hull, Mechanical, and Electrical Equipment (H,M&E) Inventory

by

John Charles Corbett
Lieutenant Commander, Supply Corps, United States Navy
B.S., Miami University, 1974
M.B.A., George Washington University, 1985

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
September 1987

ABSTRACT

Inventory standardization can increase parts availability while reducing operating costs. Although DOD and Navy policies and guidance support standardization, Navy programs have not been successful in minimizing nonstandard parts in weapon designs. This thesis attempts to identify the supply support problems caused by a lack of inventory standardization and to determine the extent of these problems. A model was developed to estimate the costs resulting from non-standardization of inventory. The model demonstrated that through inventory standardization the Navy could annually save millions of dollars. The savings achieved by reducing nonstandard parts and consolidating items with similar form, fit, and function can be re-invested in inventory to improve depth. Finally, standards offices can make a substantial contribution to the reduction of nonstandard parts if given more authority in the acquisition approval process.

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I. INTRODUCTION

A. FOCUS OF THE STUDY

While expanding to a 600 ship fleet, the Navy is coming under intense pressure to reduce operating expenses. Yet at the same time, it is fulfilling increased commitments. After several years of real growth, the ships are potentially faced with the situation of again "doing more with less". However, the build-up since 1980 has seen the introduction of a greater variety of increasingly complex weapons, and thus, this approach is not as feasible as in previous years. Should political changes erode the support, it may not be possible to maintain some of the new systems. Therefore, alternative methods must be explored to ensure that the weapons are adequately supported and ready when needed. One method of achieving this objective is through inventory standardization. By increasing the depth of a reduced range of parts, the likelihood of the specific part part being available substantially increases.

B. OBJECTIVES

The intent of this thesis is two fold: 1) It will explore the problems caused by a lack of inventory standardization, and 2) It will examine ways that increased use of standard parts can improve availability while reducing costs. It is a broad-based presentation directed towards management level personnel with emphasis on problems and issues. It is not intended to be a detailed step-by-step plan for implementing a standardization program.

During the research it was observed that within the Department of Defense, and especially the Navy, there are "pockets" of knowledge pertaining to standardization. (This includes all facets of the issue, and not just inventory.) Unfortunately, there has not been any attempt to gather the information into one central document. Therefore, an additional underlying goal of this thesis is to provide a basis for such a reference source.

C. RESEARCH QUESTIONS

In conjunction with the objectives, the primary research question addressed was: How can the Navy improve management of non-standard inventory?

To aid in the research, the following subsidiary questions were addressed:

1. What is the relationship between the acquisition process and standardization of equipment and parts?
2. How has the lack of technical documentation caused inventory ranges to expand?
3. How does Navy policy affect inventory standardization?
4. What are the potential impacts of non-standardization on the Navy's inventory levels?
5. What is being done to implement standardization?
6. What standardization costing models are available as tools in the decision process?
7. What are the costs and impacts of non-standardization?

D. RESEARCH METHODOLOGY

Research was conducted primarily through literature searches and interviews with Department of Defense (DOD), Navy, and General Accounting Office (GAO) officials. The literature reviewed included Office of Management and Budget (OMB) publications, DOD and Navy instructions and directives, GAO reports, Navy Postgraduate School and Air Force Institute of Technology (AFIT) theses, Naval Audit Service reports, and books. The interviews were conducted both in person and over the telephone. The interviews were with personnel from the Office of the Secretary of Defense, Defense Logistics Agency (DLA), Office of the Secretary of the Navy, Navy Ships Parts Control Center (SPCC), Naval Supply Systems Command, Naval Air Systems, Navy Space and Warfare Command, Naval Sea Systems Command, and Superintendent of Shipbuilding, New Orleans, La.

E. SCOPE OF THE STUDY

This study limited its scope to Hull, Mechanical, and Electrical (H,M&E) material for two reasons. First, H,M&E parts have a more stable design over an equipment's life than do electronic components. Secondly, H,M&E systems are not as complex as electronic systems and thus data analysis is easier.[1]

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[1] This is not intended to discount the applicability to the electronic field. Rather, lessons learned from H,M&E can be tailored to fit electronic parts.

The thesis examines standardization problems from the perspective of a logistician responsible for supporting operational weapon systems, with the intent of improving fleet material availability.

F. LIMITATIONS

Unfortunately, this study had to be conducted without the assistance of the Navy's Standardization Officer or her office. Repeated efforts to discuss this research were unsuccessful. As a result, we can assume that the observations made in Chapters 3 and 5 concerning the ineffectiveness of NAVSEA's standardization programs are valid.

G. ASSUMPTIONS

Throughout this thesis, it is assumed that the reader is familiar with the federal government's acquisition policies. Furthermore it is also assumed that the reader understands basic Navy, and especially Navy Supply Systems Command, terminology.

H. ORGANIZATION

The thesis is divided into an introduction, two chapters discussing problems and issues, a chapter analyzing costs, and a final chapter of conclusions and recommendations. Chapter II discusses the federal government's and DOD's acquisition policies as they pertain to standardization. Chapter III narrows the focus to the Navy's acquisition and standardization policies. Chapter IV explores three models available for determining the costs for non-standardization, and proposes a fourth model. Chapter V presents the conclusions and recommendations.

Each chapter is designed to answer at least two of the subsidiary research questions. Chapter V is structured to provide a summary of the findings for each of the questions before providing recommendations for resolving the primary question.

II. BACKGROUND

A. INTRODUCTION

Standardization is a broad field encompassing design, production, operation, and life-cycle support of a weapon system. Congress in its definition goes so far as to include equipment and ammunition commonalty amongst NATO allies.[2] Potential benefits derived from standardization can be substantial, but if current actions are indicative of managerial desires, then few within the Navy fully comprehend the impact in terms of life-cycle support. This chapter is a synopsis of the topic from the Department of Defense (DOD) perspective. The chapter first defines standardization in terms of life-cycle support. Next it summarizes the acquisition process as it affects standardization, starting with the Office of Management and Budget (OMB) guidance, the Federal Acquisition Regulation (FAR) policy, and DOD directions. After examining DOD programs for controlling part standardization it discusses the process by which a part enters the DOD catalog system. Finally it concludes with an analysis of the problems of duplication resulting jointly from managerial decisions and the Defense Logistics Service Center (DLSC) cataloging process.

---

[2] United States Code, Title 10, Chapter 145, Section 2457.

B. RESEARCH QUESTIONS

This chapter will address the research questions:

1. What is the relationship between the acquisition process and standardization of equipment and parts?

2. How has the lack of technical documentation caused inventory ranges to expand?

C. DEFINITION

Standardization is

"...the process by which the Department of Defense achieves the closest practicable cooperation among the services and Defense agencies for the most efficient use of research, development and production resources, and agrees to adopt on the broadest possible basis the use of:

(a) common or comparable operational, administrative and logistical procedures
(b) common or compatible technical procedures and criteria
(c) common, compatible, or interchangeable supplies, components, weapons or equipment
(d) common or compatible tactical doctrine with corresponding organizational compatibility."[3]

The Defense Standardization Manual (DSM), DOD 4120.3-M, states that the objectives of standardization are to:

"(1) Improve the operational readiness of the Military services.
(2) Conserve money, manpower, [and] time.
(3) Optimize the variety of items...used in...logistics support.
(4) Enhance interchangeability, reliability, and maintainability of military equipment and supplies.
(5) Ensure that products of requisite quality and minimum essential need are specified and obtained.
(6) Ensure that specifications and standards are written so as to facilitate tailoring of prescribed requirements to the particular need.

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[3] Department of Defense Dictionary of Military and Associated Terms, The Joint Chiefs of Staff, Washington, D.C., 1979, p 245.

(7) Assure that specifications and standards imposed in acquisition programs are tailored to reflect only particular needs consistent with mission requirements."[4]

The intent of these objectives, according to the DSM, is to establish and maintain "...a single system of specifications and standards to provide uniform and technically adequate records of the engineering definition of equipment and supplies as a common basis for communication of coordinated defense needs and for contractual agreement in their acquisition."[5]

D. LIFE-CYCLE SUPPORT COSTS

Standardization as it has been defined in the DSM can impact the life-cycle support costs of a weapon system more so than any other facet of an acquisition. These costs, termed Operation and Support (O&S) costs, can sometimes accrue for more than 20 years following procurement of the final piece of hardware. LCDR Porter divides O&S expenses into initial non-recurring costs (such as provisioning and documentation), and the recurring costs of personnel, material, and overhead.[6] He notes that "...funds required in supporting a system are often twice those spent in acquiring it..." and concludes that downstream costs are substantial.[7]

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[4] DOD 4120.3-M, Defense Standardization Manual, September 11, 1985, para 1-103.1 a.

[5] DOD 4120.3-M para 1-103.1 b.

[6] LCDR David L. Porter, USN, Controlling Life-Cycle Cost: A Management Perspective, Thesis, Naval Postgraduate School, Monterey, California, December 1985, p 20.

[7] Margaret A. Emmelhainz, "Innovative Contractual Approaches to Controlling Life-Cycle Costs," Defense Management Journal, Second Quarter, 1983.

Thus it is apparent that O&S costs can significantly impact a system's cost-effectiveness.

These O&S costs are comprised of:

(a) Provisioning and Technical Documentation and efforts related to provisioning
(b) Maintenance
(c) Training
(d) Technical Manuals
(e) Installation
(f) Configuration Control
(g) Testing (system as well as parts)
(h) Inventory acquisition, replenishment, management, holding, and ordering[8]

Standardization can reduce these O&S costs by:

"(1) Reduc[ing] inventory costs for spare parts since standardization infers increased depth and decreased equipment ranges.
(2) Reduc[ing] provisioning, inventory management, storage, transportation and handling and training costs.
(3) Reduc[ing] volume and associated costs for equipment configuration control, ship drawing banks, technical manuals, and maintenance plans.
(4) Improving planning for upkeeps, restricted availabilities and overhauls. More sophisticated material requirements planning programs can be used when all the ships have the same equipment baseline."[9]

LCDR Olson points out that "...the overall result is an improved fleet readiness through increased reliability and supportability."[10]

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[8] LCDR James P. Poe, SC, USN, The Management of Competitively Procured Stock Numbers, Paper presented to American Society of Naval Engineers Conference, March 25, 1987.

[9] LCDR Stephen J. Olson, SC, USN, Standardization and Competition as Applicable to New Construction Shipbuilding Programs, Unpublished paper, Naval Postgraduate School, Monterey, CA, March 1987, p 3-4.

[10] Olson, p 3-4.

E. FEDERAL ACQUISITION PROCESS

The Office of Management and Budget (OMB) Circular A-109 provides the structure for system acquisition. During design, the process must not "...conform mission needs or program objectives to any known systems or products that might foreclose consideration of alternatives."[11] This statement is telling the Project Manager (PM) that the mission's needs should not be adjusted to fit available equipment thereby excluding alternative systems. It implies that it is acceptable at that stage of a project to ignore standardization for the sake of new technology.

A-109 also requires the agency to provide the contractor with the life cycle cost factors for use "...in the evaluation and selection of the system for full-scale development and production."[12] "Selection of a system(s) and contractor(s) for full-scale development and production is to be made on the basis of (1) system performance against current mission need and program objectives, [and] (2) an evaluation of estimate acquisition and ownership costs..."[13] Despite the requirements, the Circular does not define the elements for measuring life-cycle costs.

The Federal Acquisition Regulation (FAR) states that the agency head is responsible for "...reviewing and approving acquisition plans...[and]...establishing criteria and thresholds at which ... life-cycle-

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[11] OMB Circular A-109, Major System Acquisitions dated April 5, 1976, p 8.

[12] OMB A-109, p 9.

[13] OMB A-109, p 10.

cost techniques will be used."[14] This requirement in essence stipulates that life-cycle costing procedures must be developed for use by all activities within the agency.

The acquisition strategy addresses all facets of the procurement including "...the technical, business, management, and other significant considerations that will control the acquisition."[15] Within the plan the manager shall "...discuss how life-cycle cost will be considered...[and]...if appropriate, discuss the cost model used to develop life-cycle-cost estimates."[16] However, the FAR does not specify the level of detail that the PM must provide.

The acquisition plan must also address the logistic impacts by describing "...the assumptions determining contractor or agency support...over the life of the acquisition, ...the reliability, maintainability, and quality assurance requirements,...the requirements for contractor data (including repurchase data) and data rights, their estimated cost, and the use to be made of the data,...standardization concepts, including the necessity to designate, in accordance with agency procedures, technical equipment as 'standard' so that future purchases of the equipment can be made from the same manufacturing source."[17]

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[14] Federal Acquisition Regulation (FAR), February 3, 1986, para 7.103 (g)-(h).

[15] FAR para 7.105.

[16] FAR para 7.105 (a)(3)(i).

[17] FAR para 7.105 (b)(12)(i)-(iv).

In system development solicitations the FAR requires PM's to consider items, in the design, that are already in the federal supply system or "...which the Government will be able to acquire competitively in the future if they are likely to be needed in substantial quantities during the system's service life"[18] Additionally, in a system production contract the PM "...shall consider requiring offerers to include...proposals [providing] opportunities [for] ...the Government...to obtain, on a competitive basis, items acquired in substantial quantities during the service life of the system."[19] The proposals should include provisions "...to provide the Government the right to use technical data [developed during] the contract for competitive future acquisitions, together with the cost to the Government... of acquiring such technical data."[20]

The FAR stipulates the use of full and open competition as the primary means of acquisition and, to this end, discourages any requirement that would preclude it. Specifications and descriptions must be minimized and may be stated in terms of function, performance, or design requirements. The FAR requires the agency to use function or performance when practicable, rather than design, in order to stimulate competition.[21] "...Plans, drawings, specifications, standards, or purchase descriptions shall state only the Government's actual minimum needs and

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[18] FAR para 7.106 (a)(2).

[19] FAR para 7.106 (b).

[20] FAR para 7.106 (b)(1).

[21] FAR para 10.002.

describe the supplies and/or services in a manner designed to promote full and open competition."[22]

F. DEPARTMENT OF DEFENSE POLICIES

Defense acquisitions are governed by DOD Directive 5000.1, Major System Acquisitions, and DOD Instruction 5000.2, Major System Acquisition Procedures. 5000.1 clearly states that "...a cost-effective balance must be achieved among...production and ownership costs...and system effectiveness..."[23] While DODI 4120.3 states that "...the degree and effectiveness of standardization efforts will be an issue to be addressed during DSARC and (S)SARC milestone reviews..."[24], the PM, following 5000.2 direction, is only required to submit a one line summary of the total life-cycle costs.[25] The PM, therefore, has the opportunity to make the life-cycle costs fit any budget number that will sell the system. Mr. Perkins concurs and notes that the Acquisition Strategy calls for supporting detail but, by the time an acquisition reaches the DSARC levels, the senior officials are only concerned with system feasibility.[26]

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[22] FAR para 10.004 (a)(1).

[23] DOD Directive 5000.1, Major System Acquisitions, March 12, 1986, para C.2.d.

[24] DOD Instruction 4120.3, Defense Standardization and Specification, February, 10, 1979, para E.2.

[25] DOD Instruction 5000.2, Major System Acquisition Procedures, March 12, 1986, enclosure 1. The summary includes all internal project operating costs along with equipment support costs.

[26] Interview with Mr. David Perkins, Command Standardization Officer, Space and Warfare Command, June 12-17, 1987.

DoD Directive 5000.39, Acquisition and Management of Integrated Logistic Support for Systems and Equipment, provides life-cycle management policy for systems as well as equipment. It states that, "...The primary objective of the ILS program shall be to achieve system readiness objectives at an affordable life-cycle cost. Early ILS program activity shall focus on designing desirable support characteristics into systems and on determining support requirements. Subsequent activity shall focus on acquisition, evaluation, and deployment of support resources."[27] The directive recommends consideration of explicit and visible plans for standard parts and components as a part of Milestone II, but does not require submission of the plans.[28] While the DSARC process attempts to balance program needs with life-cycle support costs, technical requirements can potentially override follow-on support considerations.

G. STANDARDIZATION PROGRAMS

The Defense Standardization and Specification Program (DSSP) was established in response to the Defense Cataloging and Standardization Act.[29] Its goal is to "...improve the operational readiness of the DOD Components and assure the cost-effective mission performance of systems

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[27] DoD Directive 5000.39, Acquisition and Management of Integrated Logistic Support for Systems and Equipment, November 17, 1983, para E.1.

[28] DOD Directive 5000.39, enclosure 1, para 3.M.(8).

[29] The original law was enacted on July 1, 1952 as Public Law 82-436, updated by P.L. 84-1028 on August 10, 1956, and codified as USC Title 10, 2451-57 in 1982. DOD Manual 4120.3-M, Defense Standardization Manual, September 11, 1985.

and equipment by fostering the efficient use of resources and optimum reuse of the products of engineering efforts."[30]

The DSSP is administered by the Defense Material Specification and Standards Office (DMSSO). It is responsible for managing all facets of standardization, of which parts and data are just a subset, and identifying areas where benefits can accrue as a result of the program.

DSSP receives Congressional attention. Annually, on January 31, DMSSO is required to submit an accomplishment report to Congress that contains:

> "(1) the number of separate specifications that have been consolidated into single specifications for use throughout the Department of Defense;
> (2) the reduction in the number of sizes or kinds of items that are generally similar; [and]
> (3) any other information that the Secretary considers will best inform Congress of the progress of the standardization program."[31]

The report includes standardization of systems, equipment, and parts as well as programs of interest to Congress such as Acquisition Streamlining, Soldering Standardization, and Acquisition and Distribution of Commercial Products.[32]

The individual services are also required to establish an office similar in function to DMSSO. The Departmental Standardization Officer

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[30] DOD Directive 4120.3, Defense Standardization and Specification, February, 10, 1979, para C.

[31] USC Title 10 Chapter 145 Section 2455 (b).

[32] Defense Material Specification and Standards Office, Defense Standardization and Specification Program (DSSP), Fifty-Sixth Report to Congress, January 1986.

(DepSO) supports the unique requirements of the service in addition to implementing DMSSO policies. When DMSSO assigns a project, the DepSO for the lead service is the focal point for the other departments.[33]

The DSSP requires that PM's use existing designs and products when practicable. It states that standardization must be an essential consideration in acquisition decisions and that the PM must minimize the number of new items introduced into the supply system. Furthermore, it dictates that, when cost-effective, standard parts must be used during full scale engineering development, production, and deployment. To this end, the DSSP requires application of the DOD Parts Control Program in system acquisitions.[34]

The DOD Parts Control Program (DOD PCP) "...promotes the use of standard parts in the design of defense systems."[35] The goal of the DOD PCP is:

"(a) To conserve resources and reduce life-cycle cost by reducing the varieties of component parts.
(b) To promote the application of established standard parts, or parts with multiple application, of known performance during the design, development, production, or modification of equipment and weapons systems.
(c) To apply engineering techniques that may assist system or equipment acquisition managers and their counterparts to identify and select established standard parts or parts with multiple application to enhance inter- or intra- departmental

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[33] Within the Navy, the Hardware Systems Commands (HSC) each have a Command Standardization Officer (ComSO) performing a similar role for their command.

[34] DOD Instruction 4120.3, para E.

[35] DOD Instruction 4120.19, DoD Parts Control Program, October 30, 1985, para C.

systems commonalty, interchangeability, reliability, maintainability, standardization, and interoperability.

(d) To standardize piece parts, potentially reducing prices through greater demand for standard parts; to reduce in varieties of parts in the inventory; to increase production runs; to enhance competition among multiple sources; and to reduce replenishment Procurement Acquisition Lead Time (PALT)."[36]

The DOD PCP Instruction delineates the responsibilities of the Military Parts Control Advisory Groups (MPCAG). MPCAG's are established at each of the DLA Stock Points. They review equipment drawings during the design phase to evaluate contractor claims of part uniqueness and therefore not stocked in the system. The MPCAG attempts to identify items within the system that have the same form, fit, and function. If the MPCAG does identify a duplicate the contractor is required to use that part unless he can demonstrate that the new part has a unique feature that cannot be satisfied with current inventory.

MIL-STD-965A "...implements the guidelines and requirements established by DODI 4120.19...and is applicable to new design and modification of existing design."[37] It notes that "...In research, exploratory development and advanced development where the design of prototype hardware is not involved, the use of standard parts is advocated, but is secondary to the prime objectives of the development."[38]

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[36] DOD Instruction 4120.19, para E.2.

[37] MIL-STD-965A, Military Standard-Parts Control Program, 13 December 1985, p iii.

[38] MIL-STD-965A, p iii.

When parts are required, the PM must invoke MIL-STD-965A in all contracts to force the contractor to use standard parts whenever possible. MIL-STD-965A states that it is the contractor's responsibility to:

"(1) Ensure efficient parts control operation.
(2) Ensure maximum use of standard parts.
(3) Minimize the number of different types and styles of parts used in the equipment or system.
(4) Ensure timely implementation of parts decisions."[39]

When the contractor disputes the MPCAG findings, it is the PM's responsibility to resolve the issue.

DOD Directive 4120.3 requires tailoring of standards and specifications to buy only actual needs. Since the PM is responsible for the technical success of the equipment, the contractor can abuse the intent of the PCP by designing the system so that few standardization benefits are achievable.

For Fiscal Years 1982 and 1983, the DOD Inspector General (DODIG) discovered that MPCAG disapproved about 11.4% of the parts submitted because of duplication but that 88% of these rejections were ignored by the PM.[40] By FY 1985 the number of rejections had risen to 12.2%.[41] If the FY 1983 cost-avoidances of $128.6M reported by the MPCAG resulting from replacement of nonstandard with standard parts are any indication of

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[39] MIL-STD-965, para 5.2.1.4.

[40] DOD Inspector General, DOD Parts Control Program Audit Report, DODIG Report 85-075, February 20, 1985, p i.

[41] Defense Standardization and Specification Program, (DSSP) Fifty-Sixth Report to Congress, January 1986, p 15.

the program's success, one can wonder how much more would be realized had the PM's not overruled the recommendations.[42]

H. PROVISIONING PROCESS

> "Before provisioning, the DoD parts control program, using the military parts control advisory groups, shall be used to control the proliferation of items within the Department of Defense and to enhance standardization, reliability, and maintainability..."[43]

Provisioning Plans should begin at item conception. When the production contract is awarded the government may buy a technical data package providing information necessary for life-cycle support. The package is separated into Engineering Information, Procurement Data, and Technical Data for Provisioning. The information specifies "...descriptive and performance characteristics or features of items, materials, methods, practices, processes and services for development, production, use and support of end items."[44] Only the latter two, Procurement Data and Technical Data for Provisioning (TDP), are pertinent to this thesis since Engineering Information applies to production methods rather than follow-on support.

"...A procurement data package provides data necessary to control design, engineering, performance, and quality of an item sufficient to ensure functional and physical adequacy of the item for its intended

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[42] DODIG Report 85-075, p 2.

[43] DOD Instruction 4140.40, Provisioning of End Items of Material, June 28, 1983, enclosure (3) para C.

[44] DLAR 4185.1, Technical Data Requirements for Logistic Support, 2 September 1977, para IV.C.

application."[45] It includes engineering drawings, standards, specifications, purchase descriptions, purchasing data, functional data, item requirement sheets, commercial catalogs, item identifications...that provide data on interchangeability [and] substitutability..."[46] The package is some combination of Performance Specifications, where the contractor builds only to form, fit, or function, or Design Specification where the contractor is required to manufacture to an explicit design.[47]

TDP provides "...identification and quantity determination(s) of spare and repair parts necessary to support and maintain end items of material for specified periods...specific elements of cataloging, engineering, maintenance and supply support data,...technical data for provisioning contain information such as piece part relationship to next higher components and assemblies, prices of parts, parts population, and replacement and overhaul factors."[48]

Supplementary Provisioning Technical Data (SPTD) is a subset of Provisioning Technical Documentation (PTD) and is synonymous with TDP.[49] "...SPTD must be capable of providing for the:

(a) technical identification of items for maintenance support considerations;
(b) preparation of item identification for the purpose of assigning National Stock Numbers;

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[45] DLAR 4185.1, para IV.C.2.

[46] DLAR 4185.1, para IV.C.2.

[47] DLAR 4185.1, para IV.C.2.a-b.

[48] DLAR 4185.1, para IV.C.3.

[49] DLAR 4185.1, para IV.C.3.

(c) review for item entry control;
(d) standardization;
(e) review for potential interchangeability and substitutability;
(f) item management coding;
(g) preparation of allowance or issue lists;
(h) initial procurement from contractor or original manufacturer."[50]

As a part of the provisioning process, the government assigns Acquisition Method Codes (AMC) and Acquisition Method Suffix Codes (AMSC) to each part. The codes provide a screen delineating whether the government can compete the part or if the source is limited. Codes can be assigned requiring the government to purchase from the original manufacturer because of proprietary restrictions. Codes can also be assigned prohibiting procurement other than on a sole-source basis because the technical package is inadequate for competition.

Congress noted that inadequate technical data restrained efforts to compete.

> "...Small businesses, in particular, indicate that they are precluded from competing for many government purchases because the government cannot provide them the data to manufacture a similar part. On the other hand, data in and of itself would not ensure that another contractor would be able to produce an equivalent part of the requisite quality. Evidence presented the committee indicates that the government's inability to retrieve data it is authorized to use and provide that information to a prospective contractor, and improper method coding of supplies, are the primary restraints on the government's ability to allow for competition for the contract.
>
> The committee believes, however, that the government is unnecessarily restricted in its replenishment spare parts purchases by initial decisions not to acquire rights in technical data because of cost (without an appropriate assessment of

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[50] DOD Instruction 4151.7, Uniform Technical Documentation for Use in Provisioning of End Items of Material, undated, para G.7.

future savings) and by failure to plan adequately for future competition when initially acquiring a system."[51]

I. CATALOGING

Congress, by legislation, tasked the Secretary of Defense with developing a single catalog system and standardizing supplies. The law specifically states that the DOD "...shall, to the highest degree practicable, standardize items used throughout the Department of Defense by developing and using single specifications, eliminating overlapping and duplicate specifications, and reducing the number of sizes and kinds of items that are generally similar."[52]

The Defense Logistics Service Center (DLSC) in Battle Creek, Michigan, is responsible for cataloging the 6 million spares and repair parts used throughout the DoD.[53] When a part is submitted to DLSC for National Stock Number (NSN) assignment, the manufacturer's Federal Supply Code for Manufacturers (FSCM) and part number (P/N) along with a full description of the part are checked for duplication. If DLSC determines that the FSCM and P/N are unique, it assigns the part a NSN. Frequently the PM only provides the FSCM and P/N because either the

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[51] Defense Spare Parts Procurement Reform Act, Committee on Armed Services Report, Report 98-690, April 18, 1984, p 15.

[52] USC Title 10 Chapter 145 Section 2451.

[53] James E. Fiene, Captain, US Air Force, The Feasibility of Using a Data Base Management System to Aid in Piece Part Standardization and Substitution, Thesis, Air Force Institute of Technology, September 1986, p 5.

contractor fails to provide the information [or PTD] or the service is in a hurry to field the equipment.[54]

The DLSC screen is dependent on the manufacturer using the same P/N in each application. "...If the contractor issues a new part number, or if the contractor has never previously contracted with the DOD, [DLSC] can do little to determine that this is a duplicate part."[55]

GAO found in March 1978 that only 37.7% of the items in the DLSC Catalog were fully described and the balance either partially described or lacked complete description.

> "...Full characteristic descriptions establish the true identity of an item and differentiate it from every other item of supply. Thus, duplicate stock numbers can be recognized and eliminated and similar items can be selected and studied for elimination of those having dispensable differences. By comparison, partially described and reference type identifications are not complete. Because all characteristics are not documented, such items are not subject to the full range of item entry controls operating in the catalog system. As a result, new items are assigned national stock numbers and added to the catalog and supply systems even though identical and similar items are already in the catalog. This duplication can remain undetected because some controls designed to identify duplicate and unneeded items depend upon the presence of characteristic data. If items are not fully described, these controls are substantially weakened."[56]

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[54] Interview with Mr. Carl Bogar, General Accounting Office, Washington, D.C. Mr. Bogar had just completed an audit of the cataloging system for release by Fall 1987.

[55] Fiene, p 9.

[56] GAO Report LCD 79-403, p 53.

While 56.3% of DLSC catalogued material was fully described, items catalogued in the Navy supply system trailed all DOD agencies with a 15.6% rate.[57]

GAO estimated that 29% of the items submitted for DLSC screening in 1977 were duplicates. Furthermore, GAO pointed out that during a trial screen, between 1974 and 1977, of the material listed in DLSC catalogs, the same percentage were determined to be duplicates.[58] The material is entering the system because the lack of data prevents effective screening.

> "...Defense and industry specialists generally agree that the most effective way to restrain the proliferation of new, unneeded items in the Federal catalog is to practice standardization at the time new equipment is designed. They realize that by the time item entry controls can operate, the Government has committed itself to buying equipment which, while meeting stated performance requirements, may contain many items for which the Government already has cataloged preferred substitutes."[59]

J. CHAPTER SUMMARY

As the chapter has shown, guidance emanating from the federal and DOD levels supports the concepts of standardization. However, the manager is told that the mission need is the most important element and that nothing should impede this goal. After all, if the requirement can be satisfied with currently available equipment, then the procurement is not necessary. Consequently, desires for the state-of-the-art potentially can take precedence over other concerns.

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[57] General Accounting Office, Fragmented Management Delays Centralized Federal Cataloging and Standardization of 5 Million Supply Items, GAO Report LCD 79-403, March 15, 1979, p 53.

[58] GAO Report LCD 79-403, p 59-63.

[59] GAO Report LCD 79-403, p 11.

DSARC does not fully consider the long range impact on system supportability. The PM is expected to base decisions on the system's cost-effectiveness, but is not provided with any measurement guidelines. Therefore procurement costs provide the only meaningful indicator.

The PM is required to use, to the maximum extent possible, material currently available in DOD inventories. The MPCAG was created to assist in this effort. Since the manager is ultimately responsible for the project's success, and not bound by the MPCAG's recommendations, if the findings are not acceptable, then the PM can use whatever the contractor recommends.

Any lack of Provisioning Technical Documentation (PTD) impacts the ability of the system to provide proper life-cycle support. By default, the government must compete the procurement using only a performance specification. As parts purchased in this manner enter the system, new NSN's must be assigned, and the inventory range swells. An adequate PTD can reduce the number of new NSN's while providing cost savings by not buying parts common to other systems until sufficient demand triggers replenishment.

III. INVENTORY LEVEL IMPACTS

A. INTRODUCTION

Chapter II summarized the applicable OMB, FAR, and DOD policies relative to standardization. It explained how a new part enters the system and the potential for duplication.

In this chapter, the impacts of non-standardization on Navy inventory levels will be addressed. It will first review Navy Guidance and the process for selecting parts. Next, it will assess the effects of competition on the inventory range. It will project Allowance Parts List (APL) and parts growth and estimate the potential number of duplicate parts either already in the Navy Supply System or entering in the near future. Finally, it concludes with a discussion of ongoing standardization programs.

B. RESEARCH QUESTIONS

This chapter will address the following research questions:

1. How does Navy policy affect inventory standardization?
2. What are the potential impacts on the Navy's inventory levels?
3. What is being done to implement standardization?

C. NAVY GUIDANCE

For the most part, Navy instructions support the goals of standardization. SECNAVINST 4120.3D states that:

"(a) Standardization shall be included in requirements for acquisition of systems and equipment.

(b) Standardized designs shall be used, with inter- and intra-system standardization of hardware and engineering practices.
(c) Existing components that are demonstrated to be reliable and supportable shall be applied in new designs.
(d) Procurement provisions shall be used to restrain proliferation of types of components."[60]

When the implementing instruction for the SECNAV standardization policy was issued, NAVMAT stated that:

> "...The Navy C/E [Component/Equipment] Program was established to curb the proliferation of components/equipment being introduced into the fleet. Proliferation of varieties of items is costly from the standpoint of economy, and efficiency of design, manufacturing and logistics. Frustrated maintenance efforts, increased logistics cost, and lack of versatility and supportability of equipment are typical of the impact on naval operating forces from a lack of standardization. Standardization of C/E is a means to reduce design and manufacturing costs, improve equipment maintenance, provide increased supportability and reduce life cycle costs. To provide for effective standardization of systems, subsystems, equipment, assemblies, components, parts and material, the Navy C/E program must be hardware oriented with increased emphasis on the concept of 'front-end' standardization (i.e. commencing standardization efforts at the beginning of the acquisition process)."[61,62]

The instruction further stated that "...effective and economical standardization controls [must] be developed and exercised during all phases of development, acquisition, and logistics support, to attain

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[60] SECNAVINST 4120.3D, Department of Defense Standardization and Specification Program (DSSP), 7 March 1980, para 3.

[61] NAVMATINST 4120.97B, Standardization of Components/Equipment (C/E) used by naval operating forces, afloat and ashore, 7 May 1984, para 4.

[62] Throughout the thesis references will be made to NAVMAT instructions. Although NAVMAT has been dis-established, many of these references remain valid.

an optimum degree of standardization and limit the variety of C/E used in weapons systems/equipment...This requires:

(a) Including hardware standardization requirements in concept formulation, design, engineering, acquisition, production, conversion, modernization and alternation.
(b) Promoting inter and intra (C/E) standardization for system designs, hardware and engineering practices.
(c) Use of (in new designs) existing, reliable and supportable C/E already supported by the military service.
(d) Restricting use of limited application C/E.
(e) Exercising configuration control to maintain standardization.
(f) Using procurement techniques to restrain proliferation.
(g) Effecting item entry control for new C/E in design, selection, and provisioning phases of material acquisition.
(h) Backfitting standardization into existing systems to maximum extent practicable.
(i) Maintaining a standardization program which is hardware oriented and recognizes that standardization is but one of many important equipment selection criteria (i.e., life cycle costs, manning, reliability, maintainability, availability, competitive procurement and industrial ability/capability)."[63]

This last statement points to the inability of the instruction's author to recognize the impact that standardization has on all the other criteria. Increased use can reduce life-cycle costs and manning requirements while improving the remainder.

NAVMAT also issued implementing guidance for the DOD Parts Control Program. In the related instruction NAVMAT stated that "...Use of the DOD Parts Control Program results in cost avoidance to the Navy by:

(a) Reducing the need for contractor-prepared drawings and specifications for nonstandard parts.
(b) Reducing redundant nonstandard parts-testing.

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[63] NAVMATINST 4120.97B, para 6.

(c) Eliminating the logistic support costs that would have accrued had the nonstandard parts entered the Logistic System.
(d) Reducing field maintenance costs through the use of more reliable parts."[64]

To achieve the objectives of the DOD PCP, according to the NAVMAT Instruction, requires "...the application of techniques that will:

(a) Provide to system or equipment acquisition program managers and their contractors methods for the selection of preferred parts.
(b) Enhance inter/intra-departmental equipment/parts standardization and interchangeability.
(c) Minimize the variety of parts used in new designs."[65]

Additionally the instruction required the Hardware Systems Commands to:

"...Enforce use of the parts control program requirements in all major system development contracts and other development, production or modification contracts when it is foreseen that life-cycle cost benefits can be derived."[66]

Despite the specificity of the SECNAV and NAVMAT Instructions, NAVSEA, in particular, excluded shipbuilding contracts from compliance with the DOD PCP in keeping with their long-standing attitude.[67] For example, a 1973 Naval Audit Service report found that 40% of all nonstandard items were generated during new construction.[68]

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[64] NAVMATINST 4120.106A, DOD Parts Control Program, 26 October 1981, para 3b.

[65] NAVMATINST 4120.106A, para 5a.

[66] NAVMATINST 4120.106A, para 5b(2).

[67] NAVSEAINST 4120.4A, Department of Defense Parts Control Program, 3 June 1983, para 3b. The instruction was superseded by NAVSEAINST 4120.4B of 25 August 1986. Shipbuilding must now comply with DOD PCP.

[68] Naval Audit Service (Northwest Region), Service-Wide Audit of Standardization of Components for Ships, report number I50033, 19

According to the Executive Director of SPCC, NAVSEA does not motivate the designer or builder. PM's and Naval Ship Yards (NSY) are evaluated on their ability to deliver the equipment by a certain date at, or below, budget. Total operating costs are not a factor. Furthermore, contractors do not have an incentive to implement a standardization program. An early attempt to provide the contractor with an incentive was unsuccessful. On the USS EISENHOWER contract (which exceeded $1B), Newport News Shipbuilding was offered $86K to incorporate standard equipment and parts. It would cost the contractor more to comply with the requirement than the return generated, thus it failed to provide a true incentive. [69]

There is a standardization office at NAVSEA. However, it does not perform any equipment analysis to evaluate potential for standardization nor do they initiate any reduction studies. Its primary role is to review contract specifications to ensure correct citation. In addition, it appears that the NAVSEA Standardization Office contributes significantly to the proliferation of non-standard items.[70]

December 1973, p 15. Despite the report's age, Mr Stanley Zatorski, the Auditor-in-Charge of a 1979 report on the same topic, did not find reason for change. Interview with Mr. Zatorski, May 22, 1987. Additional research by the author does not dispute the 1973 findings. Comparison of equipment proliferation figures in the 1973 report with a 1986 Naval Sea Systems Logistics Center "Fleet Standardization Profiles" report shows an increase in the number of new non-standard equipment.

[69] Interview with Mr. R. B. McFarland, Executive Director, SPCC, May 19, 1987.

[70] Interview with Mr. Steve Lowell, DMSSO, July 6, 1987. Mr. Lowell, who was formerly employed in the NAVSEA Standardization Office, noted that the office does not have any full-time engineers that review for non-standard equipment or parts. On the other hand, the

D. PART SELECTION PROCESS

In the previous section, it was argued that despite the numerous instructions requiring standard parts, NAVSEA would seem to be contributing to the problem through inadequate internal guidance. This section will address the problems within the equipment selection process that took advantage of the NAVSEA policy and contributed to proliferation.

Initial design and equipment selection is done by the NAVSEA engineer in the project office. Once the plans have been approved, the engineer at the lead shipyard prepares the Basic Alteration Class Drawings. The drawings provide a detailed list of the material required for the first ship, and are the baseline for subsequent ships.[71] When developing the drawings the engineer generally uses two reference sources for equipment selection. The first, the NAVSEA Standard Component List (NSCL), provides population data and standard descriptions. However, since the information is maintained on microfiche and the research tedious and time consuming, it is not used to its fullest extent.[72]

The second reference source, the Master Index of Allowance Parts Lists (MIAPL), is also maintained on microfiche. While the NSCL only supplies equipment related information, the MIAPL breaks the information down to NSN's. The engineer must know the NSN of the C/E or the APL number to access the related drawing. It is a manual process; the

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NAVAIR Standardization Office has approximately 100 engineers that initiate studies and review designs.

[71] Naval Audit Service Report, I50033, p 14.

[72] Interview with Mr. Larry Tapp, Superintendent of Shipbuilding, New Orleans, LA.,June 1987.

MIAPL does not have the facilities for accessing the information through Form, Fit, and Function (F^3) specifications. The engineer does not like to use either, but considers the MIAPL the least desirable of the two sources.[73]

The use of a centralized computer data base to aid in the search is not new. In 1970, a congressional report entitled "Military Supply Systems: Cataloging, Standardization and Provisioning of Spare Parts" recommended the development of an automated system to provide designers with standard C/E information. However, the cost of the system and the physical size made its development impractical.[74]

Captain Fiene evaluated two less complex systems. The first, Technical Logistics Reference Network (TLRN), was developed in 1973 by Innovative Technology Incorporated (ITI). Initially designed to reduce procurement and support costs, the system has the capability of performing a characteristic search. Presently, TLRN is the only system that can interrogate the entire DOD inventory by part description.[75] The system, however, is slow. It screens for one characteristic at a time and the first pass can take as long as 2-3 hours. "It is not uncommon for a complete search for a part on this system to take as long as five hours."[76]

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[73] Ibid.

[74] Fiene, p 25.

[75] Fiene, p 17-18, and 62.

[76] Fiene, p 29.

The second system was the Characteristic Search System which is part of the DLA Network. The system, developed by DLSC, is limited to searching for ten characteristics even though the engineer frequently requires more than the limit. In a test, Captain Fiene searched for 35 fasteners, each with seven characteristics. He averaged 9.5 minutes per part, a considerable time saved over the TLRN search of 5 hours.[77] Unfortunately, he noted that "...There have been no plans made to implement this system at the engineering working levels."[78]

Finally, he points out

> "...it can take as little as 30 minutes to write up justification for using a piece part not listed in the DOD supply catalog. Weigh this against taking a week to manually search for a substitute from the DOD supply catalog, when it is not even known if a substitute exists, and it is not hard to understand why the design engineer may not always build this type of standardization into a design."[79]

Based on the discussion in this section, the Naval Audit Service finding is not surprising:

> "...our review indicated that selections were based primarily on engineering knowledge of specific commercial products that met the alteration or repair requirements, without considering the adaptability of existing standard equipment."[80]

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[77] Fiene, p 65.

[78] Fiene, p 22 and 64.

[79] Fiene, p 13.

[80] Naval Audit Service (Northeast Region), Service-Wide Audit of Replacement Components for Installation on U.S. Navy Ships (Standardization), Audit Report I20047, 5 September 1979, p 5.

E. EFFECTS OF COMPETITION

Standardization and competition are not conflicting efforts. In fact standardization can boost competition by reducing the variety of parts while simultaneously increasing the quantity of each buy. Experience has shown that there is more interest by the manufacturer in competing for larger orders, and savings from competition are well-documented.

Another way that competition has increased has been through contracts citing performance rather than detailed design specifications. This does not intend to imply that considering form, fit, and function (F^3) excludes design specifications. In fact, as the U.S. Army Material Systems Analysis Activity (AMSAA) notes, F^3 can run the gamut from pure design to performance specifications.[81] However, according to the AMSAA study, the use of F^3 specifications, which allow the contractor to design the item, increases the potential for competition and enables the government to incorporate improved technology faster.[82]

The AMSAA study did find that the use of F^3 reduced standardization and led to additional NSN's. It also found that the increased configuration can lead to maintenance problems, especially for repairable material, and concluded that F^3 was better suited for generic, non-repairable items.[83]

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[81] U.S. Army Material Systems Analysis Activity, Form, Fit, and Function (FFF) Study, AMC Task Number 83-14, November 1984, p 11.

[82] AMSAA study, p 13.

[83] AMSAA study, p 31-61.

The latter observation was supported by SPCC personnel. They cite repair problems on Shipboard Air Conditioning Units where equipment was bought based on performance specifications. When the sailor tried to repair it the insides of the "black-box" differed from the technical manuals which also differed from equipment at the schools. Additionally, the ship may have more than one piece of equipment onboard and that there was a good chance that the P-250 Pumps or the Air Conditioning units were not identical. Consequently, the ship has to carry a greater range of parts if the installed population is sufficient to justify it. By reducing the variety of equipment and the supporting range, depth of spares could be increased and material availability improved.[84]

F. APL AND PARTS PROLIFERATION

Now that the root of the proliferation problem has been established, it is necessary to assess the impacts on the Navy's inventory levels. If one makes the assumption that APL growth directly corresponds with equipment introductions, then it is possible to forecast the proliferation of parts within the Navy Supply System. However, the author was concerned that examination of the total parts population might hide any trends within the equipment population. Therefore, the data was segregated into related groups and the equipment growth within the groups was then measured to develop a forecast.

APL's for H,M&E are categorized into 89 Commodity Classes (CC) (e.g. Valves, Motors, Pumps, and Controllers) within the Weapon System

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[84] Interview with Messrs. George Blackmore, and William Bunge, Equipment Specialist, SPCC, May 18, 1987.

File (WSF) at SPCC. Since all 188,731 H,M&E APL's are broken into commodity classes, the information presented in the CC format was used to analyze the equipment data.

Data was available on the annual number of new APL's within each CC from 1977 to 1986 and was used to compute the average annual growth for each CC. Forty-four of the 89 (49.44%) classes showed an average growth that exceeded the aggregate average over all CC's in at least 4 of the last 5 years (starting in 1982).

A regression analysis was performed next in an attempt to determine if the annual additions to the APL population for each of the 44 above average growth rate CC's was a function of the total annual fleet population and deliveries of new ships.[85]

The results of the regression analyses did not fully support the contention that the trends in the 44 CC's were directly attributable to fleet expansion. Only 14 of the 44 items (22.7%) had an R-Squared value greater than 70% when regressed on fleet expansion.[86] Therefore other

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[85] Ships completing Restricted Overhaul (ROH) were also considered since the Naval Audit Service finding that 60% of new equipment were added during overhaul. However, ROH's were omitted since the number steadily declined from 1977 and the number was "...expected to stay at the same low level or ...decline in the years ahead, as more ships are phased into engineering operating cycles and phased maintenance programmes." [Jane's Fighting Ships 1986-1987, p 688.] As the number of ROH's declines there will be an increase in shorter, but more frequent Ship Restricted Availability (SRA) to perform upkeep maintenance that would otherwise be restricted to ROH. Because data for both ROH and SRA were not available beyond the past five years, it was not possible to test correlation with APL proliferation.

[86] 70% was selected over the traditionally accepted R-Squared of 80% since the T-Ratios for these items were strong and indicated a

causes for the growth of the remaining 30 were investigated. Data was separately regressed against 1) total ship population, and 2) new deliveries and total ship population. If the CC had an R-Square greater than 70% and a T-Ratio greater than 2 for the latter regression, then the formula for computing APL growth included both variables. If the results only met the R-Square criterion, then the formula ignored new deliveries.

To compute the potential APL growth, 3 selection criteria were used. First, if the CC had an R-Squared for greater than 70%, the ship population for the following years was factored according to the computation derived from the regression model. Second, it was assumed that the growth from the past five years for CC's that showed the above average trend but were not correlated to ship population, would remain constant. As a result, the average annual growth since 1982 was accepted as the predictive value. Finally, along the same lines, the average annual growth of the remaining 45 CC's over the past 10 years was assumed to be constant and therefore used to compute future growth.

The formula for estimating the APL growth, of those items correlated with ship population and/or new deliveries, was:

$$\text{APL Growth} = \text{Constant} + \text{Ship Population}(X_1) + \text{New Deliveries}(X_2).$$

where X1 is the coefficient for ship population for each CC, and
X2 is the coefficient for new deliveries for each CC.

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significant regression. Using 70% as a baseline implied that less than 30% of the increase was explained by other factors and the author considered that to be acceptable. Changing the R-Squared value to 80% would have left only 6 items that could be explained by the increase in the population. Using 60% would have increased the acceptable regressions to 21.

For example, Controllers (CC 15) had an R-Square value of 90.7%. Its 1987 APL growth was 782.9 and was computed by:

$$-2{,}877 + 569(6.6062) + 13(-7.62)$$

where 569 is the 1987 ship population and 13 is the number of new ships delivered to the Navy in 1987.

Next, Pumps, CC 01, which showed an above average growth trend but was not correlated to ship population, grew an average of 479 new pumps in the past five years. Therefore, as it was assumed that this trend would continue, the value of 479 was used to estimate the 1987 pump growth.

Finally, Condensers, CC 04, was a member of the 45 slow growing CC's, and grew an average of only 11 equipment per year for the past 10 years. Thus, its growth was assumed to remain constant at 11 in 1987.

From the results of the regression analyses, the forecasted total aggregate APL growth is:

Year	Forecasted APL Growth
1987	10,737
1988	10,955
1989	11,549

The figures far exceed the average of 8,778 used by NSLC, but are less than the actual growth for 1986.[87]

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[87] NSLC computes the annual growth by averaging the growth of the individual CC's and aggregating the results. Using the data from the past 10 years, NSLC estimates that the APL population will grow by 8,778 in 1987. Interview with Mr. Richard Jones, May 18-22, 1987.

The next step, was to calculate the number of additional parts that can be expected to result from the forecasted increase in equipment. Historically, when a piece of H,M&E equipment is introduced, 25% of its parts are new to the supply system. (For electronic equipment it is 15%.) The average number of parts per equipment within each CC is also known.[88] It was then a matter of multiplying the forecasted number of APL's per CC by the parts/equipment and then by 25% to compute the expected number of new H,M&E parts being added each year to the Navy Supply System.

Using the forecasted 1987 - 1989 APL growth values projected a parts range growth of:

Year	Projected Parts Growth
1987	39,034
1988	40,006
1989	42,295

Ignoring reductions resulting from obsolescence and assuming approximately 600,000 line items are managed by SPCC, this equates to an annual parts growth of over 6% for any of the three years. With the emphasis on streamlining and funding reductions, the additional parts add an unwanted burden to an already strained system.

Data and complete regression analysis results are provided in Appendix A.

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[88] Interview with Mr. Richard Jones, May 18-22, 1987.

G. EXTENT OF DUPLICATION

In Chapter II it was shown that approximately 29% of the material in the DLSC Catalog is duplicate. As mentioned earlier, the Navy currently manages 188,731 different H,M&E equipment, but the number that are duplicate are unknown. Determining the number of duplicates requires the availability of files giving details for each equipment. Such data are maintained in the SPCC Weapon System File (WSF). However, it was not possible to screen the WSF since it is not structured to permit easy access by functional specifications.[89] The NAVSEA Logistics Center (NSLC) has developed the capability for querying the WSF by Commodity Class (CC) to obtain this data. It is being placed in NAVSEA's Component Characteristic File (CCF). However, since the CCF project is still being installed, not all information for all classes have been transferred into the CCF (e.g. within the CC for Pumps, 88.37% of capacity specifications have been transferred, while only 4% of the intake connection types transfers have been completed).

As it was not possible to screen the entire data base for duplicate equipment, it was necessary to select a representative commodity class. The findings were then extrapolated to estimate the number of duplicate equipment in the entire population. The CC 01, Pumps, was chosen since more data was available than for the other classes, and it was assumed that the size was sufficiently large to represent all equipment. The file was searched based on Lead Allowance Parts List (LAPL) description,

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[89] NSLC is restructuring the files to provide the customer with the capability to access the data. It is scheduled for completion by the end of 1987. Interview with Mr. Richard Jones, NSLC, May 18-22, 1987.

Gallons Per Minute (GPM), and Pounds Per Square Inch (PSI).[90] The data was then segregated by the number of Allowance Parts Lists (APL), Fleet Population (number of installed equipment in the fleet) and Ship Population (the number of ships with the installed equipment).

The data resulted in identification of 3,116 different pumps with similar functions. Initially, 2,376 pumps with only one APL were eliminated since they were obviously not duplicates (e.g. a centrifugal pump, boiler feed with a capacity of 655 GPM and 775 PSI). Then 8 more were eliminated since they were no longer installed. This left 732 pumps with differing GPM/PSI combinations for further examination.

The equipment was segregated by the number of APL's per similar function, and then categorized by the number of different GPM/PSI combinations. For instance, there are 2 different APL's for pumps capable of pumping 460 GPM at 1,460 PSI. (There was a total of 447 different GPM/PSI combinations, each with 2 different APL's.)

In Chapter II it was noted that GAO estimated that 29% of the items in the DLSC Catalog were duplicate. From a conservative perspective it was felt that 25% rather than 29% would yield results more acceptable to skeptical readers. Categories that had 4 or more APL's with similar characteristics were then multiplied by 25% to compute the potential number of duplicates. Assuming that there had to be duplication in the

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[90] The data was not specified other than the generics of LAPL, GPM and PSI so it is not possible to differentiate, for instance, whether the equipment were designed to pump water, gasoline, or oil.

categories that had only 2 or 3 APL's, an arbitrary value of 10% rather than 25% was used to compute potential duplicates.[91]

Based on the above assumptions, the results indicated that there were potentially 373 pumps that are identical or 5% (373/7,400) in the 01 CC. Assuming a comparable 5% for the remaining CC's, there are potentially 9,513 duplicate equipment managed by the Navy. A one-time elimination of the duplicates offers potential savings and substantially reduces the range of parts managed in the Navy Supply System.

Data used to develop the estimates and results for the Pump class (01 CC) are provided in Appendix B.

Assuming the number of duplicate equipment has been estimated correctly, the range of parts that may then be eliminated from system inventory can be estimated. Earlier it was estimated that 25% of the parts in each APL are new to the supply system when the equipment is introduced. If the 9,513 duplicate APL's are multiplied by the number of parts per equipment (as was done in section F to compute the parts growth) and the 25% factor applied, then 29,268 new parts could be potentially eliminated from entering the inventory system.

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[91] A rule of thumb in private industry is that 10% of equipment with comparable low populations (as exhibited by equipments with only 2 or 3 APL's) are duplicate. Interview with Dr. David R. Whipple, Naval Postgraduate School, Monterey, CA, June 1987.

Applying the same logic to the table of section F, the potential reductions for 1987 - 1989 could be:

Year	Duplicate APL's	New Parts
1987	541	1,968
1988	552	2,017
1989	582	2,132

While this may not appear to be a major issue, as Chapter IV shows, it offers the opportunity for significant potential cost savings.

The results of the duplicate part estimates by commodity class are provided in Appendix C.

H. SUBSTITUTABILITY

When a new item enters the system it is assigned to a family group according to the DOD interchangeability and substitutability process. The item most currently assigned to the family becomes the head of the group. As material is requisitioned, the requested item is issued but the demand is recorded against the family head. Replenishment inventory is then procured for the family head.[92]

One of the benefits of standardization purported in Chapter II is that inventory depth can be increased because the range is decreased. This implies that material availability for parts with substitutability and interchangeability (S/I) should be better than for parts without this feature.

To test this theory the WSF was queried, comparing backorders of items with S/I against parts that lacked this feature. Backorders were

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[92] Interview with LCDR Poe, May 18-22, 1987.

selected as a means of measurement since, in theory, S/I material should be able to satisfy more demand and therefore have relatively fewer outstanding procurements. If that were the case, then Supply Material Availability (SMA) (the percentage of demands satisfied immediately) for S/I items should be better than for non-S/I parts.

Only SPCC managed 1 (consumables) and 7 (repairables) Cog family items that had 10 or more NSN's and 3 or more demands per year were selected as S/I candidates. These items were chosen for two reasons. The first was that the greater the number of NSN's within the family, the greater the opportunity to satisfy demand. Second, and more importantly, using families of 10 or more NSN's reduced the population screened and made data analysis more manageable.

The results of the comparison did not prove that material availability was improved for S/I items. For the 341 S/I NSN's (Family Heads), there were 3,056 backorders whereas the 633 non-S/I NSN's experienced 5,657 backorders. S/I items had 8.96 backorders per NSN versus 8.94 per NSN for the latter, an insignificant difference. It is beyond the scope of this thesis to determine the reasons for the results, but it can be surmised that non-S/I NSN's received increased managerial attention.

I. ONGOING STANDARDIZATION PROGRAMS

Approximately 10 years ago NAVSEA initiated the Navy Standard Valve Program to standardize valves with diameters of two inches and under. At that time there were 153 APL's for valves of this size, and the Navy was achieving only a 50% Supply Material Availability (SMA). Through

the use of standardization the number of APL's dropped from 153 valves with a range of 5 parts each to 24 with a range of 12 parts while SMA exceeded 99%.

Standardization also resulted in competition increasing significantly. Twenty manufacturers bid on Navy design specifications and 5 companies were awarded contracts for the initial buy of 213,290 valves. The combination of competition and volume also permitted the manufacturers to reduce the procurement costs, off the original estimates, by 51% to $12.1 million and increase product quality. The latter has resulted in substantial life-cycle cost avoidance. Because of the value engineering improvements, it is estimated that each valve can be repaired at least five times before it is replaced. Estimates for the previous valves showed that they could not be repaired more than approximately 2 times. As a result it is estimated that the Navy will save over $700 million dollars over the life of just the originally procured valves.[93]

The P-250 Pump is a portable fire fighting/damage control pump installed on every surface ship in the Navy and Coast Guard. There are six different P-250 pumps in the fleet. The pumps, each with an expected life of two years, had been procured by performance specifications. As a result, on an average destroyer that has three P-250's, each pump may be different and the parts not interchangeable. The range of equipment reduced the inventory depth that the ship carried in

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[93] Interview with LCDR Robert Burtherus, SC, USN, SPCC and SPCC Memorandum 4400, Ser 0514/510, May 30, 1985.

stock so that when the pumps failed there was a strong possibility that the part was not in stock.

Since damage control is vital for the ship to complete its primary mission, SPCC initiated a program to standardize the pump in 1983. Using a government owned design package, SPCC competitively procured 5,000 units reducing the acquisition costs from $9,100 to $4,600 each (for a procurement savings of $22.5M) while improving the estimated reliability by 50%. Furthermore, because the APL's were reduced from 10 to 3, SPCC was able to increase depth since it was not necessary to spread funds across as great a range of parts.[94]

There is a fire pump installed in the engine room of every surface ship. The procurement costs of the 64 different pumps range from $60 to 80K each, with an economical repair cost between $45 and 60K per unit. In an effort to reduce the equipment variety, NAVSEA recently purchased the unlimited technical data rights to a titanium fire pump. Consequently the APL's were reduced from 64 to 2 and the number of wearing parts from 175 to 7. The procurement quantity of 1,328 pumps enabled the Navy to take advantage of volume discounts, cutting the acquisition costs to $26K each. At this price it is now cheaper to replace the old pumps rather than repair them.

The success of these three programs occurred because the Navy purchased technical data packages that enabled every contractor to deliver

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[94] Interview with Messrs. George Blackmore, and William Bunge, SPCC, May 18, 1987.

identical equipment. The reduction in the equipment range increased the volume for each procurement and resulted in substantial cost savings.[95]

Unfortunately, NAVSEA's philosophy on standardization is not consistent. For example, NAVSEA recently "de-standardized" the LM2500 Gas Turbine Engine, the power plant for the KIDD (DDG-993), SPRUANCE (DD-963), PERRY (FFG-7), BURKE (DDG-52), and TICONDEROGA (CG-47) Class ships. In its original configuration, the LM2500 is installed in over 95 ships. However, in an effort to improve the power, the Ship Acquisition Project Manager (SHAPM) switched from a double to a single shank starting with the CG-52 and a non-interchangeable fuel control on the DDG-57. SPCC initially managed 4,000 parts to support the engine. The changes increased the range by 20% to 4,800 parts, at an approximate additional cost of $320K per engine.[96]

It is the SHAPM's prerogative to make such decisions when the long term benefits exceed the cost. Standardization should be only one of the considerations in that decision. However, PTD must be purchased to coincide with the changing configuration if the equipment is to be properly supported during its life. In the LM2500 situation, engine modifications are currently being installed without support as the technical data package was only recently delivered. It is estimated that it will take 4 years for

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[95] Ibid.

[96] Interview with Mr. Jerry Lusk, LM2500 Manager, SPCC, May 18, 1987. The additional spares cost was computed by taking the $1.6M estimated as the cost of parts to support the engine and dividing by the 4,000 parts to compute the average cost per part. The cost/part was then multiplied by the 800 new parts (20% of the 4,000) to arrive at $320K.

the supply system to provide adequate inventory support for the parts.[97] In the LM2500 case, since the supply system may have to acquire parts based only on performance specifications, the decision to delay data procurement may ultimately contribute significantly to parts proliferation.

J. CHAPTER SUMMARY

Despite the specific directions from SECNAV and NAVMAT, past NAVSEA policy and actions have effectively resisted efforts to standardize, thus significantly contributing to inventory growth. In addition, PM's and builders are not sufficiently motivated and shipyards do not have the tools that will enable engineers to identify standard parts. As the projections show, this has resulted in an expansion of the inventory. Continuation of the growth can detrimentally impact fleet material readiness.

Recently NAVSEA took some steps to standardize (i.e. the pumps) with considerable success. The success of these standardization efforts demonstrates that the program is effective and leads to substantial payoffs.

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[97] Interview with Mr. Jerry Lusk, LM2500 Manager, SPCC, May 18, 1987. Mr. Lusk noted that the PM had not made provisions for interim support but was depending on the warranty to provide parts. The question must then be raised about parts support while the ship is underway unless the contractor is willing to provide every platform with a repair kit.

IV. COST ANALYSIS MODELS

A. INTRODUCTION

Chapter II discussed the requirement for making decisions on a cost-effective basis. In Chapter III the problem with parts proliferation was discussed. Costs are the driver in most decisions, but in neither chapter was the subject explicitly addressed. In this chapter the costs of standardization will be explored. First, three current models for measuring standardization costs will be reviewed. Next, a new model will be proposed that incorporates factors not considered by the other three models. Using the proposed model, the costs for non-standardization will be computed and the implications of the resulting non-standardization costs analyzed. Finally, the chapter will conclude with a brief discussion of the factors that must be considered in the decision to purchase Provisioning Technical Documentation (PTD).[98]

B. RESEARCH QUESTIONS

This chapter will address the following research questions:

1. What standardization costing models are available as tools in the decision process?
2. What are the costs and impacts of non-standardization?

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[98] For a thorough discussion of life-cycle costing, LCDR David L. Porter's thesis, Controlling Life-Cycle Cost: A Management Perspective, provides an outstanding analysis of the subject, and is highly recommended.

C. COSTING MODELS

1. NAVSEA Logistics Center (NSLC) Model

DOD and Navy guidance reviewed in the previous chapters specifically stated that system procurements must be cost-effective. However, nowhere is the means for measuring cost-effectiveness provided. The PM's therefore need a means for analyzing the ILS cost associated with the introduction of new equipment and for measuring the cost-effectiveness of procuring PTD. Mr. Richard Jones of NSLC has developed such a tool.

In developing the NSLC model, the following factors were determined to be important initial ILS costs related to standardization:[99]

"(a) PTD
(b) Provisioning
(c) NSN/APL Maintenance
(d) Training
(e) Technical Manuals
(f) Installation Drawings
(g) Configuration Control
(h) Testing
(i) Planned Maintenance."

The model was developed to be a part of the Request For Proposal (RFP) package. The premise is that the contractor would calculate the values for the factors based on a standard set of numbers. In that manner all competitors would be working from the same baseline. In line with A-109, the PM could then add the ILS costs to the acquisition costs to fairly assess the true costs for operating the contractor's proposed system.

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[99] Unless otherwise noted, the discussion of the NSLC model is taken from Mr. Richard Jones' paper H,M&E Standardization.

Should a contractor with the lowest bid lose the contract because total operating costs were higher, the government could potentially be sued. Therefore, the model was developed using formulas generally accepted throughout the defense industry.[100]

The resulting model is:

$$C = 950 + 171.25(P) + 67.2(P)(L) + PR(L) + 1000(CL) + 20(Pop) - 2(PR),$$

where C represents total ILS costs,
P is the number of different parts in the equipment,
L is the projected life-cycle of the equipment in years,
PR is the equipment unit price,
CL is the number of classes of ships per installation, and
Pop is the number of ships.

A detailed explanation of the model is provided in Appendix D.

2. Defense Electronic Supply Center (DESC) Model

A second model was developed by Mr. Charles E. Gastineau of the Defense Electronics Supply Center (DESC). He found that four factors account for 80% of the total life-cycle costs of a part related to standardization. They are:

"(a) The cost of preparing a document that describes the nonstandard part, taking into account the labor charges, overhead, burden, and other charges related to document preparation.
(b) The cost to test nonstandard parts which represents a major portion of the cost...
(c) The cost of managing a part in the inventory which includes the cost of provisioning meetings, computer layout sheets, etc.

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[100] Interview with Mr. Richard Jones, NSLC, Mechanicsburg, PA, May 17-22, 1987.

(d) The cost incurred in maintenance owing to the reliability or unreliability of a nonstandard part. This too is a major cost..."[101]

Using the results of two studies, Mr. Gastineau then developed a simplified technique for analyzing the cost-effectiveness for applying standardization.[102,103]

The resulting model is:

$$CA = (MH)(\$/MH)(\%ND) + (\%PT)(\$/T) + [(\$/C) + (y)(M\$/y)](\%ND)(NPN) + (y)(\$R/y),$$

where CA represents the total ILS costs,
MH is the number of manhours,
$/MH is the cost per MH,
%ND is the percentage of drawings needed for the new parts,
%PT is the percentage of parts tested which were new parts,
$/T is the average cost per test,
$/C is the cost to catalog (a one-time charge),
y is the number of years,
M$/y is the management cost per year,
NPN is the number of new parts per drawing, and
$R/y is the annual repair costs.

A detailed explanation is provided in Appendix E.

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[101] Charles E. Gastineau and Donald L. Kerr, "Don't Cry: Justify", from The Economics of Standardization, edited by Robert B. Toth, p 63.

[102] The two studies used were: (1) Charles L. McElroy and Ralph T. Rognlie, A Mathematical Model for Determination of Benefits Derived from Standardization of Electronic Parts and Components, Master's Thesis, Air Force Institute of Technology, August 1969, and (2) National Aerospace Standards Committee, Aerospace Industries Association, Standardization Savings, Identification and Calculation, NAS1524, 31 August 1970. The first reference was cited by Messrs. Gastineau and Kear in the article "Don't Cry : Justify". The second reference appears as an appendix in The Economics of Standardization.

[103] Unless otherwise noted, information for this discussion is taken from Messrs. Gastineau's and Kerr's article.

3. Aerospace Industries Association of America (AIAA)

The Aerospace Industries Association of America (AIAA) developed a third model, using nine factors, that provided the basis for the DESC model. It assumed that savings from standardization would be accrued from:

(a) Increased quantity purchases,
(b) Reduced paperwork and handling,
(c) Reduced storage requirements,
(d) Reduced engineering search time,
(e) Using a standard stock part rather than establishing a new standard,
(f) Using a standard stock part in lieu of a new design,
(g) Reduction of the inventory range,
(h) Using a stocked standard part in lieu of a nonstocked part, and
(i) Using a known design rather than detailing the data completely for a new part on the drawing.

The model requires an extensive amount of data and thus does not meet the simplification criteria necessary for PM acceptance. It is more applicable in decisions to standardize material already carried in inventory. The model is summarized in Appendix F.

4. Model Analysis

If any model is going to be accepted by the PM, then its results must provide valid numbers that can be used in decisions. To test the validity of the NSLC and DESC models, the author ran both models using common data.[104] If the results were proximate, then it could be assumed that both models provided the PM with a simplified tool. The manager could then select either one.

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[104] The AIAA model was not tested. It is more applicable in the decision to standardize equipment or parts already in use rather than estimating the cost for introducing new equipment. The latter is the goal of the NSLC or DESC models.

Mr. Gastineau assumed that each part had a life of ten years before it was redesigned or eliminated from inventory. The ten-year assumption was therefore used for both models. All costs were inflated from their base year by a 5% annual rate. The 1987-1989 APL/part growth projected in Chapter III provided three different values for the number of parts to be introduced annually. Since less than 75% of all APL's are installed on five or less ships, it was assumed that the each equipment was installed on five ships and, with such a low equipment distribution, all five ships were assumed to be from the same class. The NSLC model assumes that training ceases four years prior to equipment phase-out. If a 20-year life expectancy is used, then four years is logical. However, using only a 10-year life, training was assumed to stop two years prior to phase-out. Finally, as Mr. Gastineau observed, the four elements used in the DESC model accounted for only 80% of costs. Therefore, the DESC values were increased by dividing the results by 80%.

The models provided the following estimates of costs resulting from non-standardization:

	1987	1988	1989
NSLC	$280,828.9K	$301,956.9K	$334,580.7K
DESC	213,876.6K	230,160.8K	255,494.5K

The detailed results are provided in Appendix G.

The models provide the PM with a simplified tool, however, the differences in the results are too great to accept each at face value. In these tests certain factors were not considered. The most readily observed problem is that both models combined annual costs with one-time

charges. For instance, annual costs for managing NSN's are combined with the one-time costs for provisioning. Furthermore, neither model considers the time value of money. Without a present value model, the PM does not have a means of comparing the 1987 acquisition outlays with 1994 logistics support costs. Thus, the numbers are not meaningful. The PM needs a simple tool that provides better costing information.

D. STANDARDIZATION COSTING MODEL

The following model incorporates the best elements of both models and provides a more complete, yet easy-to-use, tool. The goal of this model is to provide the manager with a methodology for evaluating the cost for adding a piece of new non-standard equipment to the fleet. Only costs resulting from the addition of non-standard equipment are considered. The model assumes that the workloads, e.g. maintenance and training, of both standard and non-standard equipment remain constant, and therefore those costs can be ignored. One-time costs are segregated from annual recurring charges so that the PM can estimate immediate impacts versus long-term affects. Furthermore it assumes a 10 year life expectancy to allow comparison with both the NSLC and DESC models.

The model incorporates the one-time (non-recurring) costs of:

a. Provisioning
b. Non-Standard Parts Drawing Documentation
c. Testing
d. Technical Manuals
e. Installation Drawings
f. Training Equipment
g. Maintenance Aids (PMS Cards)

PTD is conspicuously absent in the model. As is explained in Appendix H, the computations for estimating the PTD costs require too many

assumptions that could cause the PM to question the credibility of the model. In addition, an argument can be made that the government already owns the drawings and does not need to pay for PTD. On the other hand, the equipment may be the manufacturer's own design and the government must pay for the complete package. In an effort to settle on a satisfactory middle ground the Non-Standard Parts Drawing Documentation element is included in the model.

The model also ignores the costs for adding a second source of supply. Once a second source has been added, the costs for maintaining the industrial base increases. The timeframe of the thesis precluded it, but the concept merits consideration.

The model also includes annual costs for:

a. Stock Number Management
b. Training Equipment Maintenance
c. Configuration Control

Costs for organic and depot maintenance have been ignored since it is assumed that the equipment will require the same amount of maintenance as the items it replaced, and therefore costs are not unique.[105] The costs for additional procurement actions, price increases resulting from volume reductions, and additional storage and handling have also been omitted. These elements are unique to each equipment and the additional complexity would detract from the simplicity. With the exception of

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[105] In theory this may not be a valid assumption since maintenance requirements for new equipment "should" be less than the equipment it replaces.

training equipment maintenance, since each training pipeline differs, it is not possible to factor training costs.

The resulting model for non-recurring costs is:

$$\{(MH)(\$/MH)[(.25P)/4](E)\} +$$
$$\{450 + \{[300(NSP) + 75(SP)](E)\}\} + \{(\%PT)(\$/T)(NSP)(E)\} +$$
$$\{62.5P + 20(Pop)\} + \{1{,}000(CL)\} + \{2PR\} + \{500\}$$

and the model for annual costs is:

$$\{448(NSP)(E)\} + \{PR\} + \{20(BRF)(NSP)(E)\}$$

where MH is the number of manhours,
$/MH is the cost per MH,
P is the number of parts per equipment,
E is the number of new equipment,
NSP is the number of Non-Standard Parts,
SP is the number of Standardized Parts per each new equipment,
%PT is the percentage of parts tested,
$/T is the average cost per test,
Pop is the number of ships
CL is the number of different ship classes per installation,
PR is the equipment unit price, and
BRF is the Best Replacement Factor.

Using the above model with the APL/Parts Growth computed in Chapter III and a 10% discount rate, the projected costs for introducing non-standard equipment and parts during 1987-1989 are:

Year	Non-Recurring Costs	Annual Costs	Life-Cycle Total Costs[106]
1987	$263,975.5K	$24,715.7K	$415,842.9K
1988	$284,770.0K	$26,566.5K	$448,009.8K
1989	$316,720.0K	$29,415.9K	$497,467.8K

The potential costs resulting from non-standardization are substantial.

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[106] Non-Recurring and ten years of Annual Costs will not sum to Total Costs. Total Costs include the present value of the Annual Costs discounted 10% at the end of each year for 10 years.

Factoring a 5% inflation rate in the annual costs increases the Life-Cycle Total Costs to:

Year	Life-Cycle Total Savings
1987	$447,001.3K
1988	$481,476.1K
1989	$521,210.8K

The results of the Standardization Costing Model indicate that the NSLC and DESC models do not provide the manager with a picture of the total costs. If one accepts the assumptions of the Standardization Costing Model, then the decision by PM's to select nonstandard parts are causing significantly higher life cycle costs than the other models project.

Appendix H provides a detailed description of the model, and the computational results are presented in Appendix I. As an illustration, the projected costs for Pumps (CC 01) are:

Year	Non-Recurring Costs	Annual Costs	Life-Cycle Total Costs[107]
1987	$ 13,026.8K	$ 1,238.1K	$ 20,633.9K
1988	$ 13,678.1K	$ 1,299.9K	$ 21,665.6K
1989	$ 14,362.0K	$ 1,364.9K	$ 22,748.9K

The results of the model demonstrate that non-standardization is annually costing the Navy approximately a half billion dollars. If the other services experience the same situation, increased standardization provides DOD with a means of appeasing spending critics. In an era of reduced funding, especially highly vulnerable Operations and Maintenance, Navy (O&M,N) funds, as well as pressure to operate more efficiently,

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[107] Non-Recurring and Annual Costs will not sum to Total Costs. Total Costs include the present value of the Annual Costs discounted 10% for 10 years.

standardization can allow the service to improve readiness without sacrificing hardware or personnel.

The next logical step is to eliminate part duplication. As noted in Chapter III, there are potentially more than 29,000 duplicate parts in the Navy supply system and approximately another 2,000 entering annually through 1989. Assuming that the non-recurring costs for the parts currently in the system have already been absorbed, so that only annual charges are incurred, and employing the Standardization Costing Model to estimate the cost for duplicates now entering, the potential life-cycle savings are:

Year	Life-Cycle Total Savings
Current	$18,828.7K
1987	2,372.1K
1988	2,521.7K
1989	2,724.4K

For instance, if the 29,268 potential duplicate parts estimated in Chapter III were eliminated, the total savings that the Navy could realize over the 10-year life cycle would be $18,828.7K. Furthermore, if the estimated 1,968 potential duplicate parts entering the Navy supply system in 1987 are precluded from doing so, an additional $2,372.1K could be saved over a 10-year life-cycle.

The savings through standardization and duplication reduction are not additive. The savings achieved by reducing duplicate parts are included in the savings achieved by parts standardization. However, the results demonstrate that reduction of non-standard parts can be achieved without paring equipment.

The projected savings do not include the personnel costs for identifying and reducing the duplicate population. Assuming that 10% of the savings will be used at $30 per hour, the funds available could provide for a team of 30 to perform the work.[108] Obviously, such a large staff is not necessary.

E. PARTS AVAILABILITY

Savings achieved by reducing the inventory range do not improve Supply Material Availability (SMA) unless some of those monies are used to increase the depths of the standardized items. While beyond the scope of this thesis to compute an individual item's SMA improvement, it is possible to estimate the relative impact on the entire parts population if only a portion of the savings are re-invested. This is done by estimating the total number of units of each standardized part that can be added to inventory.

Computing the potential number of units required several assumptions. The cost per part was not available, so it was estimated by dividing the average equipment price by the average number of parts in each equipment. Since the average number of parts per APL is known, the potential inventory range was computed by multiplying the number of parts per APL by the total number of APL's at the end of 1986. Although it was recognized that not all items are stocked, this provided an adequate baseline for the remaining calculations. Using the assumption that 25% of

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[108] This calculation assumes that the average government employee earns $30 per hour, including benefits, and is paid for 2,080 hours annually.

the parts in each APL are unique, the potential inventory range was reduced by 75% to estimate the range of different parts within each commodity class. This latter computation resulted in a range of 580,657, close to the estimated 600,000 managed by SPCC, thereby validating the calculations.[109]

In order to estimate the additional depths of parts, potential funds that could be generated through standardization and re-invested had to be estimated next. This required two calculations, one from savings achieved by reducing the annual operating expenses, and the other by reducing the non-recurring expenses.

Annual cost savings available for re-investment were first computed. It was assumed that 50% of the duplicate parts and 25% of the nonstandard parts would be eliminated. The savings achieved by these two reductions were then added to compute the initial amount of funds available from annual operating savings. To take into account the impacts of competition and increased volume, that value was then increased by 25% to estimate the potential purchasing power.

Similarly, savings available from reduction of non-recurring expenses were estimated. It was assumed that 25% of the equipment would be standardized, and those savings would be used for increasing inventory. These savings were also increased by 25% to compensate for the effects

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[109] The assumptions used in this paragraph were provided by NSLC. Interview with Mr. Richard Jones.

of competition to estimate the potential purchasing power generated by reduction of nonstandard equipment.

Finally, the potential total savings were divided by the sum of the cost per part multiplied by the inventory range to get the increase in average inventory depth for all parts. This procedure did not provide meaningful results, however, since it only computed an increase of .03 units per CC. As shown in Appendix J, very few classes had an increase of 1 or more parts per line item. Therefore, for the data to be meaningful it was aggregated by both annual and nonrecurring savings. Next, each sum was divided by the average cost per part to compute the average number of units that could be bought with the savings. Unlike the Standardization Costing Model, for ease of computation, estimates were for the first year of the life cycle, and not the remaining nine years, and thus time value of money was not a factor. These results were substantially more significant, and are provided in the following table:

Year	Annual Funds	Annual # Parts	Total Funds	Total # Parts
Dup's	NA	NA	$ 11,767.9K	13,154
1987	$ 8,464.9K	9,462	90,957.3K	101,672
1988	9,090.1K	9,677	98,080.7K	104,414
1989	10,043.9K	10,183	109,018.8K	110,532

Intuitively with a depth increase of this magnitude, SMA can only improve, and with it, so does fleet readiness.

F. TECHNICAL DATA COSTING

Throughout this thesis the importance of adequate technical documentation has been emphasized. However, Olson, Cunningham, and Wilkins noted that the costs for technical data could potentially offset the savings.[110] Therefore technical data must not be bought blindly; it requires business sense to determine when to buy it and how much to pay.

The PM must have a tool to aid in the decision of technical data viability. NSLC determined that the cost of data ownership was a function of:

a. Population
b. Unit Price
c. Savings from Competition
d. Obsolescence
e. Interest Rate
f. Equipment Complexity (i.e. the number of parts)
g. Part Replacement Rate
h. Testing and Tools
i. System Life
j. Technological State of the Art
k. Potential for Commercial Applications

Using these elements, NSLC developed the Data Ownership Analysis model. It provides a basis for "measuring the potential savings achievable through full and open competition of all requirements throughout the life cycle of an equipment. The resultant model from this analysis provides a means to determine the threshold value up to which the

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[110] Edward J. Brost, A Comparative Analysis of Sole Source Versus Competitive Prices in the Acquisition of Weapon System Replenishment Spare Parts, Master's thesis, LSSR 51-82, Air Force Institute of Technology (AFIT), Wright-Patterson Air Force Base, Dayton, Ohio, September 1982, p 31-32, referencing Alan E. Olson, James A. Cunningham, and Donald J. Wilkins, A Cost-Benefit Analysis of Competitive Versus Sole-Source Procurement of Aircraft Replenishment Spare Parts, Master's Thesis, SLSR 21-74A, AFIT, January 1974.

Government should be willing to pay for remanufacturing quality data with some probability of savings."[111] Based on the model, if the potential savings are equal to or exceed the cost of the data, then it is cost effective to buy the technical data.

To demonstrate the potential cost savings per commodity class would not provide useful information within the context of this thesis because the assumptions required to calculate the costs across the equipment spectrum are too broad to fit the individual items and would invalidate any results. However, the model does provide the PM with a useful tool, and for that reason, is presented in Appendix K.

G. CHAPTER SUMMARY

The manager needs a simple tool for determining the life cycle costs of fielding non-standard equipment. Two current models were evaluated. The DESC model, the more conservative of the two, projected the 1989 cost for non-standardization to be more than $250M. However, the differences between the two models were significant, and neither considered all factors. Thus, the Standardization Costing Model was proposed. This model incorporated cost elements of both the NSLC and DESC models as well as other factors, such as the time value of money, that those two models ignored. Using the same data, the Standardization Costing Model projected costs of more that $521M. Unlike the NSLC and DESC models, the Standardization Costing Model includes all the costs for

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[111] Mr. Richard Jones, H,M&E Standardization.

non-standardization and provides the PM with a picture of the total life cycle costs.

The potential savings are therefore substantial. Injecting part of these funds back into inventory are estimated to increase the repair parts population depth by more than 100,000 units per year. An increase of this magnitude, if wisely invested, can only improve fleet readiness.

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. INTRODUCTION

The subsidiary research questions were examined in detail in Chapters 2 through 4. In this chapter, the answers to these questions are summarized with appending conclusions. The primary research question is then addressed, and recommendations for improving management of non-standard items are offered. The chapter concludes with several areas meriting additional research.

B. RESEARCH QUESTIONS

Question 1. What is the relationship between the acquisition process and standardization of equipment and parts?

The introduction of new equipment is governed by a myriad of OMB, FAR, and DOD regulations, instructions, and directives. The primary consideration of the guidance is deployment of new technology to meet the immediate threat. Long term supportability is only a secondary issue.

System supportability is one of the factors that the PM must consider when evaluating system trade-offs. OMB Circular A-109 and DOD Directive 5000.1 require consideration of life-cycle costs as a part of the PM's decision process, but don't provide the manager with any guidelines.

Consideration of non-standard parts does not appear to be a major issue in the DSARC process. However, recently guidance have been provided to control parts proliferation. Unfortunately, nothing forces the PM to support standardization. In fact, the PM can override the

recommendations provided by Military Parts Control Advisory Groups (MPCAG) and the Departmental Standardization Officer (DepSO).

Conclusion. DOD already has the capability to control entry of non-standard parts into the system, but it does not provide any responsibility or authority to organizations which can enforce standardization. For example, if part proliferation is to be controlled, the DSARC process must give more consideration to life-cycle support issues. However, until the PM's are given the tools to facilitate making such decisions, restrictions cannot be imposed. The PM is held accountable for all his/her decisions and should not be thwarted by a bureaucratic process that does not understand the project. The DOD organization must not be an impediment to a much needed weapon system. Once the PM has the tools, then a total assessment is not only prudent, but should be evaluated during DSARC.

Question #2. How has the lack of technical documentation caused inventory ranges to expand?

Technical data needed for standardization of parts is expensive. Thus, it is not unusual for PM's to delay data procurement in order to spend the project's limited funds on hardware development. Items lacking technical data will be assigned NSN's, even if a duplicate exists, because the Defense Logistics Supply Center (DLSC) does not have the capability to compare the part with current inventory. A change in the Federal Supply Code for Manufacturers (FSCM) or Part Number (P/N) is all that is needed. The problem has been exacerbated by the lack of information available to cross check submissions. DLSC is addressing this issue but, in the meantime, the inventory ranges increase.

Conclusion. The technical data is needed to effect standardization. However, the decision to procure technical data must be based on life-cycle effectiveness. From the fleets' perspective, the onus is on the supply system to provide support even though the PM failed to purchase adequate documentation. If the PM decides against procuring the data, then the supply system should require that the PM annually provide funds for inventory support. The costs may be sufficient to force the manager to reconsider the decision. If the annual costs are expected to be insignificant and the impact on readiness inconsequential, then it was a sound business decision not to purchase data.

Question #3. How does Navy policy affect inventory standardization?

Navy policy clearly supports the goals of standardization. Yet, until recently, NAVSEA specifically excluded the shipbuilding program from standardization requirements. As a result, 40% of all the Navy's non-standard parts were generated during new construction.

NAVSEA has finally taken the first step to reduce proliferation by requiring adherence to the DOD Parts Control Program (PCP). It may take the organization's bureaucracy awhile to change direction, but NAVSEA has placed increased attention on the issue.

The issue of incentives as a means to encourage industry to increase use of standard parts has never been fully explored. A relatively insignificant attempt on the USS EISENHOWER contract did not provide Newport News Shipbuilding with a meaningful incentive.

Engineers are not provided with the capability for rapidly screening DOD inventories for common parts. The engineers must manually search microfiche copies of the NAVSEA Standard Component List (NSCL) and the Master Index of Allowance Parts Lists (MIAPL). The Technical Logistics Reference Network (TLRN) is slow and can take upwards of 5 hours to search for a part. DLA is developing a system that searches for a part based on 10 characteristics and averages 9.5 minutes per part. However, the engineer frequently needs more than the 10 character limit in order to fully identify the equipment requirements. DLA does not have plans to install the system at the working level.

In a procurement the use of performance (form, fit, and function) as the sole criteria adds to part proliferation while reducing standardization. The criteria is intended, however, to stimulate competition. If the procurement is not administered wisely, the costs of non-standardization can far outweigh the savings generated from the competition.

Conclusion. Acceptance of the standardization program can be accelerated by establishing standardization goals for PM's and Naval Ship Yard (NSY) Commanders. Additional emphasis must be also placed on increased incentives for the contractor. However, until the engineers are provided with adequate tools to aid in the parts selection process, incentives will be an ineffective method for increasing standardization. NAVSEA Logistics Center (NSLC) has made great strides to provide the tool. Unfortunately, DLA does not have any intention on providing the designer with access capability to the CSS. With pressure to meet the tight schedules and emphasis on increasing productivity, engineers can be

expected to continue to follow the path of least resistance by opting for readily identifiable non-standard parts.

Question #4. What are the potential impacts of non-standardization on the Navy's inventory levels?

Based on the tables in Chapter III, the annual number of non-standard equipment deploying is expected to increase to approximately 11,500 by 1989. This, in turn, results in an annual spare and repair parts growth of more than 42,000 by 1989.

Conclusion. As annual appropriations tighten, the funds for depth that should be purchased are being diverted to support the added range. Consequently, weapon systems may not receive adequate support. Unfortunately, all systems will be affected, not just the ones where the PM discounted standardization efforts.

Question #5. What is being done to implement standardization?

The Navy has several ongoing standardization programs. The 2-Inch and Under Valve project is expected to save the Navy over $700M dollars over the life of the equipment. Shortly, standardization of the P-250 Fire Pump and the Titanium Fire Pump will be completed with similar expectations. As a result of the reduction in the range of parts, it is anticipated that material support will significantly improve.

Conclusion. The savings along with the improved material support only lends further support to the arguments for standardization. The conclusion is self-explanatory; the efforts must continue.

Question #6. What standardization costing models are available as tools in the decision process?

If the PM is going to accept a costing model as a decision tool, then it must be simple and reliable. At the present, two models provide this, one from NSLC and another from DESC. AIAA has also developed a model, but it is far too complex to be practical and is more applicable to decisions concerning standardization of non-standard parts already in inventory.

Unfortunately, the NSLC and DESC models do not consider all costs. Both ignore the time value of money, thereby overstating the life-cycle costs. The NSLC model does not include the one-time charges for documentation and testing. Technical manuals, training equipment, maintenance aids, and configuration control are not considered by the DESC model. Therefore, a Standardization Costing Model that incorporates features from all three models (including AIAA's) was proposed. It is a simplified model that provides the PM with a more complete picture of the life-cycle costs.

Conclusion. The PM has two tools available, but, if parts proliferation is a reliable indicator, obtaining wide-spread acceptance of the models has been less than outstanding. Efforts have been undertaken recently at NAVSEA to incorporate the NSLC model into the planning process.[112] The Standardization Costing Model proposed in this thesis

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[112] Commander, Naval Sea Systems Command, Use of Total Cost Concept to Determine Performance Specification Assemblies Breakout Candidates, Letter to Commander, Naval Supply Systems Command (PML-550), 4408 OPR:CEL-MS2 Ser CEL-MS/4080, 18 May 1987.

provides an alternative. It combines simplicity with greater life-cycle cost visibility, and should be considered by the program manager.

Question #7. What are the costs and impacts of non-standardization?

Using the Standardization Costing Model developed in Chapter IV, life cycle costs resulting from continued introduction of non-standard parts will increase from $415.8M in 1987 to 497.5M in 1989. If a 5% inflation rate is factored in the computation, then the costs change to $447.0M in 1987 and $521.2M in 1989.

If a freeze on new non-standard parts is imposed, only 69% of the potential savings could be immediately realized. The remaining savings would accrue over the next several years.

It is difficult to assess the impact on Supply Material Availability (SMA) if the savings from a non-standard part freeze are re-invested in depth. However, by 1989, the expected savings could provide every ship in the KIDD (DDG-993) class with a depth increase of 1 for every authorized part.

Conclusion. The projected costs of non-standardization are astronomical. If the assumptions used to develop the model are acceptable, then savings from standardization can both increase inventory depth, and reduce logistics costs and operating expenses. Fleet readiness will be the ultimate benefactor.

C. RECOMMENDATIONS

The remainder of this chapter is devoted to the primary research question: How can the Navy improve management of non-standard inventory? The recommendations are oriented towards two separate parties:

1. Navy Supply Systems activities, and
2. Policy setting organizations.

1. Supply System Recommendations

Improved SMA, and hence fleet readiness, is the primary issue addressed by this section. The secondary issue, considered in conjunction with the primary goal, is cost reduction.

To resolve these issues requires a four-step approach. The first step is reduction of duplicate parts already in the system. The second is identification of similar parts that lend themselves to consolidation. The third step is re-investment of savings for increased depth, and the fourth is education to sustain the standardization effort.

The fastest way to reduce the range is through elimination of duplicate parts. This elimination enables the supply system to invest more monies in the remaining inventory. The NSLC CCF Modernization project, when completed, will provide the capability to rapidly screen the data base and hence improve identification of existing parts during the design phase.

The next step is consolidation of items that have similar characteristics but are not identical. It encompasses identification of parts with high failure rates (BRF's) and low population. An arbitrary starting point would be with parts that have a BRF of 50% or more, are

used on five or fewer platforms, and which 75% of the characteristics are identical.[113] A fourth decision parameter may be parts that have experienced a C-3 or C-4 Casualty Report (CASREPT) within the past year or which have the potential for causing a CASREPT. As the parts are identified, decisions to redesign parts or equipment for substitutability or interchangeability (S/I) should be made with the consent of the Hardware Systems Command (HSC). It is the responsibility of the HSC to assess the impact on mission performance that such a change may cause.

The AIAA model provided in Chapter IV can assist with the decision to redesign the part. It provides the engineer, logistician, and HSC a tool for comparing cost savings for standardizing the parts. The costs can then be compared with potential for improved SMA allowing the PM to make an informed decision. Again, the NSLC CCF project, when completed, will permit the engineer to screen the SPCC data base for the applicable parts.

Potential cost savings should be a criterion in determining which items to consolidate. However, it should be pointed out that costs are of secondary concern; SMA is the primary issue. The analysis recommended above can begin in the areas where savings potential are greatest. This enables the engineer to concentrate on effectiveness while exacting the greatest return in savings.

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[113] The selection of a 50% BRF was strictly arbitrary. The value for 5 ships was selected since over 73% of the APL's are found on 5 or fewer ships.

The timing of a reduction in range should coincide with an increase in depth. This can only transpire if the funds saved are quickly made available for re-investment.[114] Unfortunately, the potential savings forecast in Chapter IV are funds from different sources (e.g. O&M,N, NSF, WPN, and OPN). It will take the concurrence of the individual weapon system sponsors to "trade" for the applicable appropriations.

Finally, it is essential that an educational program be undertaken so that managers in headquarters activities fully comprehend the detrimental effects of non-standardization and the savings which can result from standardization. Only with the concurrence and, most importantly, the sustained support of the decision makers, will the benefits of standardization be realized.

2. Other Recommendations

Resolving the problem of non-standardization requires support from all echelons, from Secretariat to the HSC level to the supply system. Once support is garnered from the top, then it is likely that everyone else will fall in line.

A proponent must be established within SECNAV, and it is appropriate to assign the responsibility to the Competition Advocate's Office (CAO). The wherewithal is available as the CAO already

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[114] Reduction of part range without an increase in depth is essentially nothing more than elimination of inventory without replenishment. As non-standard items are issued, replacement orders are not placed and, as such, fewer requisitions can be satisfied from on hand inventory.

reviews specifications. It is a natural extension and it allows the office to operate in a business strategy role.

Throughout the thesis it has been noted that while programs have been established they are often not fully supported financially. One of the reasons has been the standards offices' lack of authority with respect to acquisition decisions. This can quickly be alleviated by providing the CAO with "control of the purse strings." As acquisition strategies of the individual projects are reviewed, standardization efforts can be assessed. If the program is unsatisfactory, then funding can be withheld. In this manner, the PM still has the authority to reject the MPCAG's recommendation, but the PM must persuade the CAO that it was a wise decision.

An alternative is to make the MPCAG and standards offices' recommendations a part of the DSARC/SSARC process. During milestone reviews, the PM would then address the project's standardization efforts. This must begin with the very first review since once approval is given to Full Scale Engineering and Development (FSED) it becomes too costly to change a non-standard part to a standard one.

The HSC's also need to provide their internal standards programs with increased authority and an appropriate mission. Currently, the role of the NAVSEA Standardization Office is to review specifications rather than initiate programs. Goals are set based on the number of specifications reviewed and brought up to date. It is work that must be done but the goal reenforces a relatively ineffective program. Priorities

of the NAVSEA Office can be reset by establishing a goal for savings (not a percentage, but actual dollar values) rather than workload. In this manner then the office can take a proactive role.

Once the mission is redefined, then the offices will have the ability to assist PM's in standardization efforts. Furthermore, they can play a role similar to the CAO. PM's are always looking for additional monies. By providing the Command Standardization Officer (ComSO) with a portion of the HSC's budget, the ComSO can fund individual project's standardization programs offering the greatest return. It not only gives the ComSO more authority, but also offers the PM another incentive to use standard parts.

D. FUTURE RESEARCH

This thesis has presented a preliminary evaluation of Navy related problems caused by non-standard parts. In the course of this evaluation many areas surfaced that offered potential for further research.

All thesis research concentrated on Department of Defense and Navy problems. There is also a vast amount of experience outside the government, and DOD can learn from the standardization lessons of companies such as Ford, American Airlines, and Sears. Many of their lessons can be readily applied to the supply system.

The Standardization Costing Model used many assumptions, some necessarily arbitrary. For instance the costs for configuration control were based on experience rather than substantive data. The intent of the model was not to perfectly predict the costs for non-standardization, but

rather to provide the PM with a decision-making tool. The assumptions used must be validated. Once that is completed, then the model should be microscopically examined to ensure that it is not overlooking an important variable. In this manner the PM can be assured that the model is an effective tool.

The thesis was written from the perspective of a logistician and, as such, issues that appear to be problems may not be viewed the same way by the PM. The PM has many other problems, all clamoring for attention. Issues such as standardization may not receive the same priority an inventory oriented person may give it. The views of the PM must be addressed if this issue is to be completely understood.

One of the goals of this thesis was that it would form the basis for a central reference source. It has accomplished this goal, but there is much more to standardization than inventory. Training programs, technical manuals, maintenance procedures, and intermediate and depot level repair programs are also affected by the lack of commonalty. For all involved to fully understand the issue of standardization, a future undertaking must address these areas.

APPENDIX A : APL AND PARTS GROWTH DATA

Appendix A summarizes the data used to develop the APL and Parts Growth estimates and the results of the model. Data for the Ship Population table, A.1, was provided by Chief of Naval Operations, OP-90K. NSLC supplied the information from the WSF for the APL Data table, A.2. The data for A.2 is presented in two parts since not all data could be printed on one page. The APL Statistical Summary table, A.3, provides the statistics and regression analysis results used in estimating APL growth for each commodity class. Numbers enclosed in parentheses () denote negative values. Table A.3 is also presented in two parts. The final table, APL and Part Growth Results, A.4, shows the growth of equipment and parts by each commodity class.

A.1 Ship Population

Nomenclature	1977	1978	1979	1980	1981	1982	1983
Total Ships	477	468	473	488	491	514	514
Deliveries	14	15	11	12	15	25	18

	1984	1985	1986	1987	1988	1989
Total Ships	524	545	555	569	582	605
Deliveries	15	16	11	13	8	19

Nomenclature	Commodity Class	1977	1978	1979	1980	1981	1982	1983	1984
PUMPS	1	272	365	211	222	173	381	403	610
BOILERS	2	7	7	5	15	5	6	8	12
HEAT EXCHANGERS	3	50	56	37	30	34	56	52	65
CONDENSERS	4	12	10	11	12	6	13	8	12
TURBINES	5	21	14	14	13	14	26	12	15
COMPRESSORS	6	37	46	37	32	24	54	35	66
HEATERS	7	208	189	155	115	142	188	130	122
DISTILLING PLANTS	8	12	10	6	8	6	15	10	9
BATTERY CHANGERS	9	13	8	18	16	16	19	24	44
METERS	10	14	15	10	12	11	29	13	20
CONVERTERS	11	15	16	16	53	15	33	37	37
TRANSFORMERS	13	0	0	5	37	15	5	4	8
CIRCUIT BREAKERS	14	183	131	110	186	69	146	115	125
CONTROLLERS	15	408	246	225	308	277	518	446	573
GENERATORS	16	20	25	24	25	24	90	58	75
MOTORS	17	563	579	331	468	558	1,097	906	839
MOTOR GENERATORS	18	9	5	6	4	4	11	3	13
RELAYS	19	33	29	49	172	41	55	48	27
RHEOSTATS	20	2	1	2	9	3	9	3	9
SWITCHES	21	190	173	181	180	174	323	292	222
SWITCHBOARDS	22	56	53	56	66	32	53	101	66
VISUAL ALARMS	23	5	5	8	9	8	23	20	17
LIGHTING FIXTURES	24	9	15	5	15	10	33	50	41
GYRO COMPASSES	25	10	22	17	13	6	40	33	14
PROJECTION EQUIP	26	0	1	0	1	0	1	1	5
I/C EQUIP	27	29	54	30	55	27	68	78	35
NAVIGATIONAL EQUIP	28	2	4	14	2	5	18	10	24
INJECTORS	29	0	4	1	2	0	2	1	2
BURNERS	30	7	5	1	0	7	2	3	7
MARINE HARDWARE	31	36	32	45	24	13	27	32	68
REFRIG EQUIP	32	175	192	176	166	109	321	345	337
AIR CONDITIONING	33	32	19	42	10	25	19	27	25
STARTERS	34	12	9	5	8	1	13	9	17
WIPERS	35	5	14	2	4	0	8	5	8
AUDIBLE ALARMS	36	1	1	5	6	1	9	9	8
BEARINGS	37	2	7	14	3	3	14	14	11
INDICATORS	38	82	95	126	74	87	116	142	133
CLUTCHES	39	3	3	1	3	11	3	9	13
FANS	40	80	55	29	128	99	84	71	79
SHOP EQUIP	41	169	138	93	80	130	217	218	189
REGULATORS	42	13	14	13	23	9	21	16	25
GALLEY EQUIP	43	75	111	91	67	100	208	200	180
DEHYDRATORS	44	8	12	9	9	6	11	11	14
GAGES	45	73	124	95	65	71	112	186	138
TESTING EQUIP	46	22	27	29	26	240	69	59	46
FILTERS	48	158	134	133	144	78	193	189	178
PANELS	50	124	176	130	229	333	171	271	190

Nomenclature	Commodity Class	1977	1978	1979	1980	1981	1982	1983	1984
ISOLATORS	51	1	Ø	Ø	Ø	Ø	Ø	Ø	1
HYDRALIC EQUIP	52	35	47	25	28	17	32	91	83
CAPSTANS	53	3	2	2	4	3	6	5	3
REELS	55	11	11	6	13	4	2Ø	27	21
DAVITS	56	3	1	3	1	Ø	7	7	3
CRANES	57	28	9	4	3Ø	Ø	1Ø	3	3
HOISTS	58	46	46	17	28	17	2Ø	34	37
ELEVATORS	59	21	7	18	25	4	13	5	8
STEERING EQUIP	6Ø	1	3	Ø	2	1	5	5	2
CONTROL EQUIP	61	175	244	328	363	334	315	318	369
WINCHES	62	14	18	15	5	7	33	35	37
WINDLASSES	63	3	4	4	4	1	5	3	6
FIREFIGHTING EQUIP	64	39	31	2Ø	27	3Ø	52	59	35
LUBRICATORS	65	1Ø	15	12	6	7	12	18	17
ENGINES	66	34	3Ø	33	28	25	36	35	45
PLUMBING EQUIP	67	3	13	8	11	5	13	15	3
GEARS AND REDUCERS	69	44	47	18	46	31	35	43	75
GOVERNORS	7Ø	14	4	12	6	8	33	2Ø	35
IGNITION EQUIP	71	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø
EJECTORS	73	1Ø	5	2	2	2	4	4	4
EDUCTORS	74	Ø	Ø	Ø	Ø	Ø	2	2	3
STRAINERS	75	87	196	9Ø	9Ø	79	1Ø2	54	123
PURIFIERS	76	26	12	5	4	9	21	16	19
TRAPS-STEAM	77	12	16	16	1Ø	7	14	8	13
COUPLINGS	78	14	23	1Ø	3Ø	14	47	37	42
SILENCING EQUIP	79	Ø	2	4	Ø	4	11	5	6
BRAKES	8Ø	19	23	12	55	22	26	44	39
BLOWERS	81	22	8	1Ø	16	1Ø	4	3	6
WELDING SYSTEMS	82	22	26	7	11	16	34	39	37
BOAT PROPULSION	83	18	12	2Ø	21	22	31	16	3Ø
DECK MACHINERY	85	69	55	63	41	43	69	65	13
PHOTOGRAPHIC EQUIP	86	1	1	2	1	7	Ø	2	3
UNDERWATER LOG EQUIP	87	2	7	3	1	1	Ø	Ø	2
VALVES	88	1,598	2,458	1,991	1,961	1,871	2,Ø51	1,289	1,579
MISC PARTS	89	6Ø	1Ø7	396	166	1Ø6	47	633	461
LAUNDRY EQUIP	91	38	28	27	25	29	1Ø9	64	75
TANKS	92	24	9	5	17	16	26	27	27
PIPE, HOSE, & FITTINGS	93	2	3	6	9	Ø	4	1	4
ASW EQUIP	94	Ø	8	6	Ø	Ø	6	6	16
YELLOW GEAR	95	1,2Ø4	1,Ø13	1,5Ø9	1,358	1,162	1,193	1,555	821
PERISCOPES	97	13	16	11	Ø	Ø	5	7	2
MISC EQUIP	99	28	56	26	68	17	43	81	71
GRAND TOTALS		7,Ø11	7,867	7,37Ø	7,662	6,953	9,426	9,398	8,952

Nomenclature	1985	1986	Total APL's	1983 Ave Equip Price	Fleet Population
PUMPS	448	555	7,400	8,957	118,070
BOILERS	7	11	198	17,898	1,525
HEAT EXCHANGERS	94	95	1,675	6,846	30,242
CONDENSERS	8	15	797	8,492	7,354
TURBINES	22	39	905	124,067	11,769
COMPRESSORS	62	76	808	18,298	12,943
HEATERS	242	226	2,523	1,042	97,449
DISTILLING PLANTS	11	10	320	15,429	3,473
BATTERY CHANGERS	40	49	290	3,339	5,188
METERS	43	41	439	2,664	8,081
CONVERTERS	38	55	657	8,254	15,116
TRANSFORMERS	5	8	878	388	102,412
CIRCUIT BREAKERS	231	203	3,971	276	887,873
CONTROLLERS	765	819	11,812	494	159,326
GENERATORS	53	65	704	75,291	10,273
MOTORS	1,038	1,025	14,014	3,433	177,056
MOTOR GENERATORS	11	9	351	25,366	3,094
RELAYS	66	58	1,543	213	92,811
RHEOSTATS	16	4	509	657	8,050
SWITCHES	376	469	9,260	403	1,039,502
SWITCHBOARDS	133	116	2,839	7,218	16,058
VISUAL ALARMS	14	66	615	489	273,672
LIGHTING FIXTURES	28	36	1,035	115	1,404,922
GYRO COMPASSES	12	33	806	5,863	23,541
PROJECTION EQUIP	1	4	54	0	3,753
I/C EQUIP	38	47	1,286	2,429	266,648
NAVIGATIONAL EQUIP	25	41	322	422	9,447
INJECTORS	9	11	71	1,552	31,610
BURNERS	10	8	109	14,362	4,509
MARINE HARDWARE	44	77	1,573	1,375	41,252
REFRIG EQUIP	339	390	3,407	9,527	62,866
AIR CONDITIONING	32	27	206	3,442	4,747
STARTERS	32	29	216	7,894	4,512
WIPERS	5	8	178	61	11,301
AUDIBLE ALARMS	6	16	99	5,857	1,006
BEARINGS	13	19	632	14,606	11,126
INDICATORS	138	276	2,192	1,318	98,042
CLUTCHES	7	10	146	29,547	3,134
FANS	136	161	2,292	2,389	92,019
SHOP EQUIP	238	174	3,208	1,245	21,365
REGULATORS	29	24	884	1,169	15,603
GALLEY EQUIP	206	222	2,142	6,441	30,416
DEHYDRATORS	14	13	247	16,455	4,629
GAGES	92	122	3,252	1,303	66,000
TESTING EQUIP	63	98	637	2,262	17,445
FILTERS	240	192	3,563	1,903	131,577
PANELS	242	376	4,265	1,908	81,303

Namenclature	1985	1986	Tatal APL's	1983 Ave Equip Price	Fleet Papulation
ISOLATORS	1	Ø	2Ø	4,836	986
HYDRALIC EQUIP	184	2ØØ	1,368	31,718	21,55Ø
CAPSTANS	6	5	14Ø	27,236	1,Ø59
REELS	28	25	3Ø6	2,27Ø	8,29Ø
DAVITS	2	12	191	14,Ø65	1,ØØ1
CRANES	1Ø	14	3Ø7	81,52Ø	1,295
HOISTS	45	63	717	2,616	4,551
ELEVATORS	13	9	74Ø	6,31Ø	4,759
STEERING EQUIP	4	1Ø	132	Ø	683
CONTROL EQUIP	479	463	6,785	972	35Ø,227
WINCHES	34	63	742	27,93Ø	5,74Ø
WINDLASSES	3	2	162	2Ø,595	872
FIREFIGHTING EQUIP	92	6Ø	345	2,661	74,Ø92
LUBRICATORS	14	8	253	1,11Ø	8,458
ENGINES	85	67	5Ø6	62,971	6,777
PLUMBING EQUIP	9	2Ø	259	Ø	7Ø,414
GEARS AND REDUCERS	79	83	1,349	37,715	18,731
GOVERNORS	5Ø	38	39Ø	1Ø,515	6,511
IGNITION EQUIP	Ø	1	4	2,88Ø	712
EJECTORS	4	7	415	9,653	4,Ø46
EDUCTORS	4	6	369	2,684	5,939
STRAINERS	81	17Ø	4,191	92	147,895
PURIFIERS	27	47	267	18,Ø78	4,996
TRAPS-STEAM	24	13	1,Ø14	314	117,576
COUPLINGS	72	66	942	14,574	46,51Ø
SILENCING EQUIP	11	1	161	682	2,68Ø
BRAKES	37	57	828	1,729	8,997
BLOWERS	5	6	24Ø	8,Ø61	7,279
WELDING SYSTEMS	33	47	367	Ø	3,376
BOAT PROPULSION	23	64	9Ø9	4Ø,5Ø4	7,528
DECK MACHINERY	22	41	1,663	3,52Ø	31,59Ø
PHOTOGRAPHIC EQUIP	5	7	72	Ø	2,176
UNDERWATER LOG EQUIP	Ø	5	2Ø7	6,169	6,716
VALVES	2,Ø7Ø	2,814	59,254	18Ø	4,118,68Ø
MISC PARTS	175	117	2,398	1,Ø1Ø	31,842
LAUNDRY EQUIP	1Ø4	85	561	5,5Ø7	1Ø,346
TANKS	9	27	764	37,532	1Ø,353
PIPE, HOSE, & FITTINGS	3	6	139	5,878	3,3Ø2
ASW EQUIP	14	8	7Ø	1Ø,735	698
YELLOW GEAR	864	1,39Ø	1,787	Ø	42,385
PERISCOPES	Ø	1	361	7,762	5,75Ø
MISC EQUIP	99	39	1,7Ø6	248	768,456
GRAND TOTALS	1Ø,546	12,595	188,731		11,499,934

A.3 APL Statistical Summary

Nomenclature	10 Yr Ave	5 Yr Ave	Constont Coeff	Totol Coeff	Deliveries Coeff	Constont T-Ratio	Totol Ships T-Rotio	Deliveries T-Ratio
PUMPS	364	479						
BOILERS	8	9						
HEAT EXCHANGERS	57	72						
CONDENSERS	11	11						
TURBINES	19	23						
COMPRESSORS	47	59						
HEATERS	172	182						
DISTILLING PLANTS	10	11						
BATTERY CHANGERS	25	35						
METERS	21	29						
CONVERTERS	32	40						
TRANSFORMERS	9	6						
CIRCUIT BREAKERS	150	164						
CONTROLLERS	459	624	(2,877.000)	6.60620		(7.62)	8.85	
GENERATORS	46	68	(285.370)	0.558300	3.249000	(4.13)	4.05	3.19
MOTORS	740	981						
MOTOR GENERATORS	8	9						
RELAYS	58	51						
RHEOSTATS	6	8						
SWITCHES	258	336	(1,295.500)	3.07690		(4.97)	5.97	
SWITCHBOARDS	73	94						
VISUAL ALARMS	18	28						
LIGHTING FIXTURES	24	38						
GYRO COMPASSES	20	26						
PROJECTION EQUIP	1	2						
I/C EQUIP	46	53						
NAVIGATIONAL EQUIP	15	24	(169.330)	0.36410		(4.61)	5.01	
INJECTORS	3	5						
BURNERS	5	6						
MARINE HARDWARE	40	50						
REFRIG EQUIP	255	346	(1,191.000)	2.86400		(4.06)	4.93	
AIR CONDITIONING	26	26						
STARTERS	14	20						
WIPERS	6	7						
AUDIBLE ALARMS	6	10						
BEARINGS	10	14						
INDICATORS	127	161						
CLUTCHES	6	8						
FANS	92	106						
SHOP EQUIP	165	207	(475.600)	1.053000	7.143000	(2.80)	3.11	2.86
REGULATORS	19	23						
GALLEY EQUIP	146	203						
DEHYDRATORS	11	13						
GAGES	108	130						
TESTING EQUIP	68	67						
FILTERS	164	198						
PANELS	224	250						

A.3 APL Statistical Summary

Nomenclature	10 Yr Ave	5 Yr Ave	Constont Coeff	Tatol Coeff	Deliveries Caeff	Constant T-Ratia	Total Ships T-Ratia	Deliveries T-Ratio
ISOLATORS	Ø	Ø						
HYDRALIC EQUIP	74	118	(893.9ØØ)	1.9174Ø		(4.63)	5.Ø2	
CAPSTANS	4	5	(16.31Ø)	Ø.Ø35178	Ø.161110	(3.52)	3.8Ø	2.36
REELS	17	24	(1Ø6.78Ø)	Ø.24437		(3.93)	4.54	
DAVITS	4	6						
CRANES	11	8						
HOISTS	35	4Ø						
ELEVATORS	12	1Ø						
STEERING EQUIP	3	5						
CONTROL EQUIP	339	389						
WINCHES	26	4Ø	(225.6ØØ)	Ø.4985Ø		(4.18)	4.67	
WINDLASSES	4	4						
FIREFIGHTING EQUIP	45	6Ø						
LUBRICATORS	12	14						
ENGINES	42	54						
PLUMBING EQUIP	1Ø	12						
GEARS AND REDUCERS	5Ø	63						
GOVERNORS	22	35	(217.26Ø)	Ø.47387		(5.44)	6.ØØ	
IGNITION EQUIP	Ø	Ø						
EJECTORS	4	5						
EDUCTORS	2	3	(32.1Ø5)	Ø.Ø6695		(9.5Ø)	1Ø.Ø2	
STRAINERS	1Ø7	1Ø6						
PURIFIERS	19	26						
TRAPS-STEAM	13	14						
COUPLINGS	36	53	(299.71Ø)	Ø.66392		(6.51)	7.3Ø	
SILENCING EQUIP	4	7						
BRAKES	33	41						
BLOWERS	9	5						
WELDING SYSTEMS	27	38						
BOAT PROPULSION	26	33						
DECK MACHINERY	48	42						
PHOTOGRAPHIC EQUIP	3	3						
UNDERWATER LOG EQUIP	2	1						
VALVES	1,968	1961						
MISC PARTS	227	287						
LAUNDRY EQUIP	58	87	(1,Ø96.8ØØ)	2.3549Ø		(4.14)	4.5Ø	
TANKS	19	23						
PIPE, HOSE, & FITTINGS	4	4						
ASW EQUIP	6	1Ø						
YELLOW GEAR	1,2Ø7	1165						
PERISCOPES	6	3						
MISC EQUIP	53	67						
GRAND TOTALS	8,778	1Ø,183						

Nomenclature	R-Squared
PUMPS	
BOILERS	
HEAT EXCHANGERS	
CONDENSERS	
TURBINES	
COMPRESSORS	
HEATERS	
DISTILLING PLANTS	
BATTERY CHANGERS	
METERS	
CONVERTERS	
TRANSFORMERS	
CIRCUIT BREAKERS	
CONTROLLERS	90.70%
GENERATORS	81.60%
MOTORS	
MOTOR GENERATORS	
RELAYS	
RHEOSTATS	
SWITCHES	81.70%
SWITCHBOARDS	
VISUAL ALARMS	
LIGHTING FIXTURES	
GYRO COMPASSES	
PROJECTION EQUIP	
I/C EQUIP	
NAVIGATIONAL EQUIP	75.80%
INJECTORS	
BURNERS	
MARINE HARDWARE	
REFRIG EQUIP	75.30%
AIR CONDITIONING	
STARTERS	
WIPERS	
AUDIBLE ALARMS	
BEARINGS	
INDICATORS	
CLUTCHES	
FANS	
SHOP EQUIP	74.90%
REGULATORS	
GALLEY EQUIP	
DEHYDRATORS	
GAGES	
TESTING EQUIP	
FILTERS	
PANELS	

Nomenclature	R-Squared
ISOLATORS	
HYDRALIC EQUIP	75.90%
CAPSTANS	76.80%
REELS	72.10%
DAVITS	
CRANES	
HOISTS	
ELEVATORS	
STEERING EQUIP	
CONTROL EQUIP	
WINCHES	73.10%
WINDLASSES	
FIREFIGHTING EQUIP	
LUBRICATORS	
ENGINES	
PLUMBING EQUIP	
GEARS AND REDUCERS	
GOVERNORS	81.80%
IGNITION EQUIP	
EJECTORS	
EDUCTORS	92.60%
STRAINERS	
PURIFIERS	
TRAPS-STEAM	
COUPLINGS	86.90%
SILENCING EQUIP	
BRAKES	
BLOWERS	
WELDING SYSTEMS	
BOAT PROPULSION	
DECK MACHINERY	
PHOTOGRAPHIC EQUIP	
UNDERWATER LOG EQUIP	
VALVES	
MISC PARTS	
LAUNDRY EQUIP	71.70%
TANKS	
PIPE, HOSE, & FITTINGS	
ASW EQUIP	
YELLOW GEAR	
PERISCOPES	
MISC EQUIP	
GRAND TOTALS	

A.4 APL and Part Growth Results

Nomenclature	1987 Projected APL Growth	1988 Projected APL Growth	1989 Projected APL Growth	1987 Add New Ports	1988 Add New Parts	1989 Add New Ports
PUMPS	479	479	479	2,036	2,036	2,036
BOILERS	8	8	8	188	188	188
HEAT EXCHANGERS	57	57	57	114	114	114
CONDENSERS	11	11	11	25	25	25
TURBINES	19	19	19	537	537	537
COMPRESSORS	59	59	59	1,136	1,136	1,136
HEATERS	172	172	172	215	215	215
DISTILLING PLANTS	11	11	11	44	44	44
BATTERY CHANGERS	25	25	25	94	94	94
METERS	21	21	21	16	16	16
CONVERTERS	40	40	40	230	230	230
TRANSFORMERS	9	9	9	2	2	2
CIRCUIT BREAKERS	150	150	150	375	375	375
CONTROLLERS	882	968	1,120	3,528	3,871	4,479
GENERATORS	75	66	114	317	279	485
MOTORS	981	981	981	1,226	1,226	1,226
MOTOR GENERATORS	9	9	9	27	27	27
RELAYS	58	58	58	73	73	73
RHEOSTATS	6	6	6	8	8	8
SWITCHES	455	495	566	455	495	566
SWITCHBOARDS	73	73	73	274	274	274
VISUAL ALARMS	18	18	18	27	27	27
LIGHTING FIXTURES	38	38	38	48	48	48
GYRO COMPASSES	20	20	20	190	190	190
PROJECTION EQUIP	2	2	2	39	39	39
I/C EQUIP	46	46	46	184	184	184
NAVIGATIONAL EQUIP	38	43	51	426	479	573
INJECTORS	3	3	3	20	20	20
BURNERS	5	5	5	45	45	45
MARINE HARDWARE	40	40	40	80	80	80
REFRIG EQUIP	439	476	542	1,097	1,190	1,354
AIR CONDITIONING	26	26	26	85	85	85
STARTERS	14	14	14	105	105	105
WIPERS	6	6	6	21	21	21
AUDIBLE ALARMS	10	10	10	25	25	25
BEARINGS	14	14	14	18	18	18
INDICATORS	161	161	161	403	403	403
CLUTCHES	8	8	8	38	38	38
FANS	92	92	92	46	46	46
SHOP EQUIP	216	194	297	433	389	594
REGULATORS	23	23	23	104	104	104
GALLEY EQUIP	203	203	203	660	660	660
DEHYDRATORS	13	13	13	72	72	72
GAGES	130	130	130	163	163	163
TESTING EQUIP	68	68	68	272	272	272
FILTERS	198	198	198	495	495	495
PANELS	224	224	224	672	672	672

A.4 APL and Port Growth Results

Nomencloture	1987 Projected APL Growth	1988 Projected APL Growth	1989 Projected APL Growth	1987 Add New Parts	1988 Add New Parts	1989 Add New Parts
ISOLATORS	Ø	Ø	Ø	Ø	Ø	Ø
HYDRALIC EQUIP	197	222	266	1,133	1,277	1,53Ø
CAPSTANS	6	5	8	22	2Ø	3Ø
REELS	32	35	41	1Ø5	115	133
DAVITS	4	4	4	7	7	7
CRANES	11	11	11	99	99	99
HOISTS	35	35	35	166	166	166
ELEVATORS	12	12	12	78	78	78
STEERING EQUIP	5	5	5	71	71	71
CONTROL EQUIP	339	339	339	1,1Ø2	1,1Ø2	1,1Ø2
WINCHES	58	65	76	377	419	494
WINDLASSES	4	4	4	35	35	35
FIREFIGHTING EQUIP	6Ø	6Ø	6Ø	285	285	285
LUBRICATORS	14	14	14	35	35	35
ENGINES	42	42	42	4,578	4,578	4,578
PLUMBING EQUIP	1Ø	1Ø	1Ø	23	23	23
GEARS AND REDUCERS	5Ø	5Ø	5Ø	363	363	363
GOVERNORS	52	59	69	9Ø3	1,Ø1Ø	1,198
IGNITION EQUIP	Ø	Ø	Ø	Ø	Ø	Ø
EJECTORS	5	5	5	19	19	19
EDUCTORS	6	7	8	3	3	4
STRAINERS	1Ø7	1Ø7	1Ø7	8Ø	8Ø	8Ø
PURIFIERS	26	26	26	611	611	611
TRAPS-STEAM	14	14	14	14	14	14
COUPLINGS	78	87	1Ø2	78	87	1Ø2
SILENCING EQUIP	7	7	7	5	5	5
BRAKES	41	41	41	62	62	62
BLOWERS	9	9	9	11Ø	11Ø	11Ø
WELDING SYSTEMS	38	38	38	181	181	181
BOAT PROPULSION	26	26	26	46	46	46
DECK MACHINERY	48	48	48	132	132	132
PHOTOGRAPHIC EQUIP	3	3	3	9	9	9
UNDERWATER LOG EQUIP	2	2	2	15	15	15
VALVES	1,968	1,968	1,968	2,952	2,952	2,952
MISC PARTS	227	227	227	3,632	3,632	3,632
LAUNDRY EQUIP	243	274	328	1,7Ø2	1,916	2,295
TANKS	23	23	23	29	29	29
PIPE, HOSE, & FITTINGS	4	4	4	4	4	4
ASW EQUIP	1Ø	1Ø	1Ø	13Ø	13Ø	13Ø
YELLOW GEAR	1,2Ø7	1,2Ø7	1,2Ø7	3,Ø18	3,Ø18	3,Ø18
PERISCOPES	6	6	6	5Ø	5Ø	5Ø
MISC EQUIP	53	53	53	93	93	93
GRAND TOTALS	1Ø,737	1Ø,955	11,549	39,Ø34	4Ø,Ø06	42,295

APPENDIX B : DUPLICATE PART DATA

Appendix B provides the data used to estimate the potential number of duplicate H,M&E parts and equipment. NSLC provided the data used for the Potential Duplicate Pump Data table from the Commodity Configuration File. The method used to develop the data in the Duplicate Percentages table was described in Chapter III.

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-ØØ1	3ØØ.ØØØ		456.ØØØ	2	1Ø	43
Ø1-ØØ1	3ØØ.ØØØ		467.ØØØ	2	6	24
Ø1-ØØ1	46Ø.ØØØ		1,46Ø.ØØØ	2	2Ø	124
Ø1-ØØ1	65Ø.ØØØ		775.ØØØ	2	3	12
Ø1-ØØ2	2ØØ.ØØØ		775.ØØØ	2	4	7
Ø1-ØØ2	5ØØ.ØØØ		125.ØØØ	2	4	12
Ø1-ØØ2	75.ØØØ		5Ø.ØØØ	2	6	6
Ø1-ØØ2	Ø.Ø25		1ØØ.ØØØ	2	16	36
Ø1-ØØ2	4ØØ.ØØØ		125.ØØØ	2	8	33
Ø1-ØØ2	Ø.Ø4Ø		4ØØ.ØØØ	2	67	138
Ø1-ØØ2	95.ØØØ		765.ØØØ	2	15	28
Ø1-ØØ2	2ØØ.ØØØ		1ØØ.ØØØ	2	4	6
Ø1-ØØ2	1.7ØØ		1,6ØØ.ØØØ	2	23	5Ø
Ø1-ØØ2	5.ØØØ		3,ØØØ.ØØØ	2	18	56
Ø1-ØØ2	9Ø.ØØØ		62.5ØØ	2	7	28
Ø1-ØØ2	Ø.Ø43		1,1ØØ.ØØØ	2	3Ø	56
Ø1-ØØ2	225.ØØØ		5Ø.ØØØ	2	4	24
Ø1-ØØ2	2ØØ.ØØØ		5Ø.ØØØ	2	5	9
Ø1-ØØ2	1Ø.ØØØ		6Ø.ØØØ	2	1	5
Ø1-ØØ3	25,ØØØ.ØØØ		2Ø.ØØØ	2	4	16
Ø1-ØØ3	3,45Ø.ØØØ		25.ØØØ	2	1	2
Ø1-ØØ3	1Ø,5ØØ.ØØØ		11.69Ø	2	3	8
Ø1-ØØ3	16,ØØØ.ØØØ		13.ØØØ	2	12	24
Ø1-ØØ3	4,9ØØ.ØØØ		24.5ØØ	2	3	6
Ø1-ØØ3	25,ØØØ.ØØØ		13.ØØØ	2	5	13
Ø1-ØØ3	25,ØØØ.ØØØ		13.5ØØ	2	5	15
Ø1-ØØ3	18,ØØØ.ØØØ		7.5ØØ	2	2Ø	2Ø
Ø1-ØØ3	22,ØØØ.ØØØ		7.5ØØ	2	3	3
Ø1-ØØ4	25.ØØØ		5Ø.ØØØ	2	6	8
Ø1-ØØ5	1Ø.ØØØ		35.ØØØ	2	6	12
Ø1-ØØ5	27.ØØØ		35Ø.ØØØ	2	11	53
Ø1-ØØ5	5ØØ.ØØØ		6Ø.ØØØ	2	1	5
Ø1-ØØ5	35.ØØØ		3,ØØØ.ØØØ	2	12	24
Ø1-ØØ5	7Ø.ØØØ		1,145.ØØØ	2	31	167
Ø1-ØØ5	35.ØØØ		35Ø.ØØØ	2	3	5
Ø1-ØØ5	5ØØ.ØØØ		55.ØØØ	2	41	84
Ø1-ØØ5	15Ø.ØØØ		1ØØ.ØØØ	2	2	5
Ø1-ØØ5	297.ØØØ		65.ØØØ	2	15	3Ø
Ø1-ØØ5	15Ø.ØØØ		8ØØ.ØØØ	2	55	132
Ø1-ØØ5	15.ØØØ		4ØØ.ØØØ	2	2	8
Ø1-ØØ5	35.ØØØ		4Ø.ØØØ	2	5	14
Ø1-ØØ5	15.ØØØ		1,Ø5Ø.ØØØ	2	3	6
Ø1-ØØ5	39.ØØØ		5Ø.ØØØ	2	5	52
Ø1-ØØ5	15.ØØØ		45.ØØØ	2	5	18
Ø1-ØØ5	3Ø.ØØØ		65.ØØØ	2	3	5
Ø1-ØØ5	26.ØØØ		3,ØØØ.ØØØ	2	4	12
Ø1-ØØ5	1.5ØØ		5.ØØØ	2	11	39

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-ØØ5	5.ØØØ		5Ø.ØØØ	2	2	3
Ø1-ØØ5	85.ØØØ		12Ø.ØØØ	2	91	332
Ø1-ØØ5	6Ø.ØØØ		4Ø.ØØØ	2	2	6
Ø1-ØØ5	1Ø.ØØØ		2,5ØØ.ØØØ	2	11	19
Ø1-ØØ5	53.ØØØ		4Ø.ØØØ	2	13	26
Ø1-ØØ5	36Ø.ØØØ		75.ØØØ	2	12	24
Ø1-ØØ5	5Ø.ØØØ		1ØØ.ØØØ	2	12	12
Ø1-ØØ5	5ØØ.ØØØ		5Ø.ØØØ	2	12	53
Ø1-ØØ5	55Ø.ØØØ		5Ø.ØØØ	2	3	5
Ø1-ØØ5	275.ØØØ		5Ø.ØØØ	2	11	4Ø
Ø1-ØØ5	16.ØØØ		35Ø.ØØØ	2	2	2
Ø1-ØØ5	5.ØØØ		3ØØ.ØØØ	2	5	46
Ø1-ØØ5	3ØØ.ØØØ		45.ØØØ	2	8	15
Ø1-ØØ5	44Ø.ØØØ		6Ø.ØØØ	2	11	26
Ø1-ØØ5	5Ø.ØØØ		3Ø.ØØØ	2	4	1Ø
Ø1-ØØ5	18.ØØØ		85.ØØØ	2	99	383
Ø1-ØØ5	3Ø.ØØØ		3Ø.ØØØ	2	19	38
Ø1-ØØ5	5Ø.ØØØ		25.ØØØ	2	3	16
Ø1-ØØ5	9Ø.ØØØ		25.ØØØ	2	2Ø	4Ø
Ø1-ØØ5	75Ø.ØØØ		5Ø.ØØØ	2	4	18
Ø1-ØØ5	6ØØ.ØØØ		55.ØØØ	2	23	46
Ø1-ØØ5	72Ø.ØØØ		5Ø.ØØØ	2	5	1Ø
Ø1-ØØ5	11.ØØØ		3Ø.ØØØ	2	3	14
Ø1-ØØ5	2Ø.ØØØ		7Ø.ØØØ	2	2	2
Ø1-ØØ5	24Ø.ØØØ		6Ø.ØØØ	2	32	37
Ø1-ØØ5	24.6ØØ		85.ØØØ	2	3	12
Ø1-ØØ5	475.ØØØ		5Ø.ØØØ	2	27	55
Ø1-ØØ5	2Ø.ØØØ		5Ø.ØØØ	2	12	27
Ø1-ØØ5	25Ø.ØØØ		1ØØ.ØØØ	2	3	8
Ø1-ØØ5	71Ø.ØØØ		6Ø.ØØØ	2	4	8
Ø1-ØØ5	1ØØ.ØØØ		25.ØØØ	2	4	5
Ø1-ØØ5	47.ØØØ		18.ØØØ	2	4	17
Ø1-ØØ5	3Ø.ØØØ		4ØØ.ØØØ	2	11	29
Ø1-ØØ5	5Ø.ØØØ		72Ø.ØØØ	2	2	8
Ø1-ØØ6	6.5ØØ		2.2ØØ	2	1	3
Ø1-ØØ7	15.ØØØ		5Ø.ØØØ	2	57	12Ø
Ø1-ØØ7	4.3ØØ		15Ø.ØØØ	2	2	8
Ø1-ØØ7	2Ø.ØØØ		1ØØ.ØØØ	2	14	2Ø
Ø1-ØØ7	4.5ØØ		1ØØ.ØØØ	2	1	3
Ø1-ØØ7	17.ØØØ		5Ø.ØØØ	2	8	27
Ø1-ØØ7	3Ø.7ØØ		6ØØ.ØØØ	2	1	4
Ø1-ØØ7	15.ØØØ		25.ØØØ	2	9	1Ø
Ø1-ØØ7	1ØØ.ØØØ		5Ø.ØØØ	2	7	11
Ø1-ØØ7	4Ø.ØØØ		25.ØØØ	2	3	5
Ø1-ØØ7	1ØØ.ØØØ		25.ØØØ	2	4	5
Ø1-ØØ7	4.ØØØ		25.ØØØ	2	43	99
Ø1-ØØ7	6.ØØØ		5Ø.ØØØ	2	9	32

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-ØØ7	42.ØØØ		85.ØØØ	2	9	49
Ø1-ØØ7	5.ØØØ		5Ø.ØØØ	2	2	3
Ø1-ØØ7	1Ø.ØØØ		42.ØØØ	2	8	18
Ø1-ØØ7	75.ØØØ		6Ø.ØØØ	2	6	27
Ø1-ØØ7	1.5ØØ		75.ØØØ	2	21Ø	572
Ø1-ØØ7	35.ØØØ		4ØØ.ØØØ	2	8	16
Ø1-ØØ8	25.ØØØ		25.ØØØ	2	8	19
Ø1-ØØ8	5.8ØØ		1ØØ.ØØØ	2	21	35
Ø1-ØØ8	6.5ØØ		1ØØ.ØØØ	2	187	327
Ø1-ØØ8	1.41Ø		1ØØ.ØØØ	2	3	4
Ø1-ØØ8	8.ØØØ		6Ø.ØØØ	2	9	54
Ø1-ØØ8	3.ØØØ		3Ø.ØØØ	2	1Ø	46
Ø1-ØØ8	22.ØØØ		1ØØ.ØØØ	2	22	177
Ø1-ØØ8	15.ØØØ		5Ø.ØØØ	2	13	24
Ø1-ØØ8	3.5ØØ		55.ØØØ	2	1	8
Ø1-ØØ8	2.ØØØ		2ØØ.ØØØ	2	49	61
Ø1-ØØ8	12.ØØØ		4Ø.ØØØ	2	2	8
Ø1-ØØ9	8.ØØØ		1ØØ.ØØØ	2	15	35
Ø1-ØØ9	6.ØØØ		3Ø.ØØØ	2	1	8
Ø1-ØØ9	11.ØØØ		2,ØØØ.ØØØ	2	13	75
Ø1-ØØ9	35.ØØØ		1ØØ.ØØØ	2	3	5
Ø1-ØØ9	11.ØØØ		1ØØ.ØØØ	2	2	3
Ø1-ØØ9	15.3ØØ		2,ØØØ.ØØØ	2	2	8
Ø1-ØØ9	11.ØØØ		2,5ØØ.ØØØ	2	3Ø	49
Ø1-ØØ9	2.5ØØ		1,5ØØ.ØØØ	2	7	3Ø
Ø1-ØØ9	1Ø.ØØØ		5Ø.ØØØ	2	6	6
Ø1-ØØ9	4.7ØØ		1,ØØØ.ØØØ	2	13	39
Ø1-ØØ9	1Ø.ØØØ		3,ØØØ.ØØØ	2	11	13
Ø1-ØØ9	15.ØØØ		2,ØØØ.ØØØ	2	8	48
Ø1-ØØ9	25.ØØØ		2Ø.ØØØ	2	3	12
Ø1-ØØ9	2Ø.ØØØ		5Ø.ØØØ	2	2	3
Ø1-ØØ9	125.ØØØ		1ØØ.ØØØ	2	2	2
Ø1-ØØ9	12.ØØØ		1ØØ.ØØØ	2	86	153
Ø1-ØØ9	1ØØ.ØØØ		8Ø.ØØØ	2	39	75
Ø1-ØØ9	1.5ØØ		1,5ØØ.ØØØ	2	13	129
Ø1-ØØ9	1ØØ.ØØØ		6Ø.ØØØ	2	38	44
Ø1-ØØ9	38.ØØØ		1ØØ.ØØØ	2	29	56
Ø1-ØØ9	35.ØØØ		775.ØØØ	2	3	1Ø
Ø1-ØØ9	5.ØØØ		5ØØ.ØØØ	2	12	13
Ø1-ØØ9	8.ØØØ		1,5ØØ.ØØØ	2	31	35
Ø1-ØØ9	7.4ØØ		5ØØ.ØØØ	2	81	119
Ø1-ØØ9	2Ø.ØØØ		7Ø.ØØØ	2	7	8
Ø1-ØØ9	2ØØ.ØØØ		125.ØØØ	2	12	33
Ø1-ØØ9	15.ØØØ		1,5ØØ.ØØØ	2	1	3
Ø1-ØØ9	6.ØØØ		2,ØØØ.ØØØ	2	5	1Ø
Ø1-ØØ9	7.5ØØ		1ØØ.ØØØ	2	4	4
Ø1-Ø1Ø	7.ØØØ		3,ØØØ.ØØØ	2	5	28

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø1Ø	181.ØØØ		5,ØØØ.ØØØ	2	8	8
Ø1-Ø1Ø	46.ØØØ		5,ØØØ.ØØØ	2	7	54
Ø1-Ø1Ø	29.ØØØ		1,5ØØ.ØØØ	2	8	8
Ø1-Ø1Ø	6.5ØØ		2,5ØØ.ØØØ	2	11	11
Ø1-Ø1Ø	61.ØØØ		3,5ØØ.ØØØ	2	4	8
Ø1-Ø1Ø	11Ø.ØØØ		1,9ØØ.ØØØ	2	11	77
Ø1-Ø1Ø	5.ØØØ		1,5ØØ.ØØØ	2	14	17
Ø1-Ø1Ø	119.ØØØ		5,ØØØ.ØØØ	2	5	7
Ø1-Ø1Ø	59.ØØØ		3,ØØØ.ØØØ	2	9	18
Ø1-Ø1Ø	1Ø.ØØØ		1,1ØØ.ØØØ	2	2	3
Ø1-Ø1Ø	2Ø2.29Ø		3,ØØØ.ØØØ	2	4	8
Ø1-Ø1Ø	77.5ØØ		2,ØØØ.ØØØ	2	4	13
Ø1-Ø1Ø	5.ØØØ		1,ØØØ.ØØØ	2	14	27
Ø1-Ø1Ø	62.4ØØ		2,4ØØ.ØØØ	2	16	32
Ø1-Ø1Ø	56.3ØØ		1,35Ø.ØØØ	2	4	12
Ø1-Ø1Ø	18Ø.ØØØ		4,1ØØ.ØØØ	2	3	6
Ø1-Ø1Ø	34.9ØØ		5,ØØØ.ØØØ	2	3	6
Ø1-Ø1Ø	9.ØØØ		3,ØØØ.ØØØ	2	2	5
Ø1-Ø1Ø	56.2ØØ		3,ØØØ.ØØØ	2	3	4
Ø1-Ø1Ø	122.ØØØ		95Ø.ØØØ	2	4	4Ø
Ø1-Ø1Ø	55.ØØØ		3,ØØØ.ØØØ	2	2	3
Ø1-Ø1Ø	48.ØØØ		3,ØØØ.ØØØ	2	7	29
Ø1-Ø1Ø	37.5ØØ		3,ØØØ.ØØØ	2	6	48
Ø1-Ø1Ø	9.ØØØ		2,ØØØ.ØØØ	2	9	18
Ø1-Ø1Ø	15.7ØØ		2,ØØØ.ØØØ	2	1	2
Ø1-Ø1Ø	148.8ØØ		3,ØØØ.ØØØ	2	2	4
Ø1-Ø1Ø	116.7ØØ		3,5ØØ.ØØØ	2	3	7
Ø1-Ø1Ø	175.ØØØ		2,ØØØ.ØØØ	2	7	25
Ø1-Ø1Ø	2Ø.ØØØ		2,5ØØ.ØØØ	2	1Ø	91
Ø1-Ø11	75.ØØØ		6Ø.ØØØ	2	8	23
Ø1-Ø11	3Ø.ØØØ		3.ØØØ	2	1Ø	27
Ø1-Ø11	7ØØ.ØØØ		15.ØØØ	2	6	21
Ø1-Ø11	4Ø.ØØØ		5Ø.ØØØ	2	17	33
Ø1-Ø11	1ØØ.ØØØ		15.ØØØ	2	2	2
Ø1-Ø11	1,62Ø.ØØØ		75.ØØØ	2	5	32
Ø1-Ø11	2ØØ.ØØØ		3Ø.ØØØ	2	3	11
Ø1-Ø11	4Ø.ØØØ		3Ø.ØØØ	2	1	2
Ø1-Ø11	72Ø.ØØØ		75.ØØØ	2	13	45
Ø1-Ø11	34Ø.ØØØ		48.ØØØ	2	3	7
Ø1-Ø11	2Ø.ØØØ		4Ø.ØØØ	2	6	13
Ø1-Ø11	2,575.ØØØ		14.ØØØ	2	2	8
Ø1-Ø11	5Ø.ØØØ		25.ØØØ	2	2	4
Ø1-Ø11	1,2ØØ.ØØØ		15Ø.ØØØ	2	4	15
Ø1-Ø11	5Ø.ØØØ		8Ø.ØØØ	2	8	18
Ø1-Ø11	45.ØØØ		5Ø.ØØØ	2	2	5
Ø1-Ø11	2Ø.ØØØ		1Ø.ØØØ	2	2	2
Ø1-Ø11	9ØØ.ØØØ		6Ø.ØØØ	2	4	16

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø11	913.ØØØ		45.ØØØ	2	2	6
Ø1-Ø11	3ØØ.ØØØ		9Ø.ØØØ	2	6	12
Ø1-Ø11	1,25Ø.ØØØ		4Ø.ØØØ	2	3	4
Ø1-Ø11	12Ø.ØØØ		37.3ØØ	2	1	2
Ø1-Ø11	3ØØ.ØØØ		35.6ØØ	2	2	6
Ø1-Ø11	35Ø.ØØØ		22.3ØØ	2	1	2
Ø1-Ø11	1ØØ.ØØØ		3Ø.ØØØ	2	171	514
Ø1-Ø11	28Ø.ØØØ		3Ø.ØØØ	2	1	3
Ø1-Ø11	2,5ØØ.ØØØ		12.ØØØ	2	3	13
Ø1-Ø11	9ØØ.ØØØ		5Ø.ØØØ	2	1	8
Ø1-Ø11	25.ØØØ		15.ØØØ	2	15	2Ø
Ø1-Ø11	4Ø.ØØØ		43.ØØØ	2	3	6
Ø1-Ø11	1ØØ.ØØØ		39.ØØØ	2	52	264
Ø1-Ø11	15.ØØØ		17.5ØØ	2	4	4
Ø1-Ø11	5.ØØØ		1Ø.ØØØ	2	3	4
Ø1-Ø11	1Ø.ØØØ		22.ØØØ	2	7	14
Ø1-Ø11	2ØØ.ØØØ		2Ø.ØØØ	2	3	7
Ø1-Ø11	25Ø.ØØØ		33.ØØØ	2	2	9
Ø1-Ø11	1Ø.ØØØ		15.ØØØ	2	2	3
Ø1-Ø11	1Ø.ØØØ		35.ØØØ	2	2	2
Ø1-Ø11	1Ø.ØØØ		6Ø.ØØØ	2	1	4
Ø1-Ø11	25Ø.ØØØ		125.ØØØ	2	5	5
Ø1-Ø11	3,2ØØ.ØØØ		12.ØØØ	2	3	17
Ø1-Ø11	15.ØØØ		75.ØØØ	2	1	4
Ø1-Ø11	4ØØ.ØØØ		3Ø.ØØØ	2	2	18
Ø1-Ø11	52Ø.ØØØ		6Ø.ØØØ	2	2	3
Ø1-Ø11	1ØØ.ØØØ		48.ØØØ	2	2	4
Ø1-Ø11	15.ØØØ		8.ØØØ	2	32	42
Ø1-Ø11	18Ø.ØØØ		28.ØØØ	2	1	4
Ø1-Ø11	6.ØØØ		15.ØØØ	2	3	8
Ø1-Ø11	25.ØØØ		4.ØØØ	2	1	2
Ø1-Ø11	85Ø.ØØØ		3Ø.ØØØ	2	2	5
Ø1-Ø11	45Ø.ØØØ		3Ø.ØØØ	2	7	12
Ø1-Ø11	24Ø.ØØØ		65.ØØØ	2	2	6
Ø1-Ø11	7ØØ.ØØØ		45.ØØØ	2	39	78
Ø1-Ø11	225.ØØØ		24.ØØØ	2	8	13
Ø1-Ø11	675.ØØØ		6Ø.ØØØ	2	2	8
Ø1-Ø11	1,5ØØ.ØØØ		65.ØØØ	2	5	2Ø
Ø1-Ø11	65Ø.ØØØ		1ØØ.ØØØ	2	5	38
Ø1-Ø11	9Ø.ØØØ		5Ø.ØØØ	2	5	12
Ø1-Ø11	65Ø.ØØØ		3Ø.ØØØ	2	2	6
Ø1-Ø11	8ØØ.ØØØ		75.ØØØ	2	2	6
Ø1-Ø11	175.ØØØ		125.ØØØ	2	7	14
Ø1-Ø11	45Ø.ØØØ		1ØØ.ØØØ	2	3	3
Ø1-Ø11	1,ØØØ.ØØØ		35.ØØØ	2	2	6
Ø1-Ø11	5Ø.ØØØ		34.ØØØ	2	3	3
Ø1-Ø11	575.ØØØ		7Ø.ØØØ	2	2	4

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø11	5Ø.ØØØ		18.ØØØ	2	4	1Ø
Ø1-Ø11	5.ØØØ		15.ØØØ	2	4	6
Ø1-Ø11	1,15Ø.ØØØ		62.ØØØ	2	5	7
Ø1-Ø11	1ØØ.ØØØ		69.ØØØ	2	2	4
Ø1-Ø11	35Ø.ØØØ		29.ØØØ	2	2	5
Ø1-Ø11	16Ø.ØØØ		34.ØØØ	2	1	3
Ø1-Ø11	1Ø2.ØØØ		74.ØØØ	2	27	54
Ø1-Ø11	16Ø.ØØØ		35.ØØØ	2	2	4
Ø1-Ø11	7Ø.ØØØ		11.ØØØ	2	4	1Ø
Ø1-Ø11	3Ø.ØØØ		5Ø.ØØØ	2	4	7
Ø1-Ø11	7Ø.ØØØ		3Ø.ØØØ	2	4	9
Ø1-Ø11	1,3ØØ.ØØØ		122.ØØØ	2	5	12
Ø1-Ø11	7Ø.ØØØ		25.ØØØ	2	2	8
Ø1-Ø11	1Ø.ØØØ		3Ø.ØØØ	2	21	82
Ø1-Ø11	1,75Ø.ØØØ		168.ØØØ	2	22	74
Ø1-Ø11	153.ØØØ		1ØØ.ØØØ	2	4Ø	4Ø
Ø1-Ø11	12,5ØØ.ØØØ		27.ØØØ	2	6	24
Ø1-Ø11	15Ø.ØØØ		15.ØØØ	2	5Ø	127
Ø1-Ø11	25Ø.ØØØ		35.ØØØ	2	6	13
Ø1-Ø11	5.ØØØ		2.ØØØ	2	46	139
Ø1-Ø11	85Ø.ØØØ		35.ØØØ	2	2	9
Ø1-Ø11	4Ø.ØØØ		15.ØØØ	2	2	2
Ø1-Ø11	8Ø.ØØØ		22.ØØØ	2	2	3
Ø1-Ø11	35.ØØØ		75.ØØØ	2	9	12
Ø1-Ø11	1,5ØØ.ØØØ		45.ØØØ	2	6	5
Ø1-Ø11	15Ø.ØØØ		99.ØØØ	2	1	2
Ø1-Ø11	85Ø.ØØØ		9Ø.ØØØ	2	48	99
Ø1-Ø11	625.ØØØ		25.ØØØ	2	3	12
Ø1-Ø11	78Ø.ØØØ		6Ø.ØØØ	2	2	4
Ø1-Ø11	575.ØØØ		29.ØØØ	2	2	6
Ø1-Ø11	575.ØØØ		23.ØØØ	2	4	12
Ø1-Ø11	1,3ØØ.ØØØ		14.ØØØ	2	1	2
Ø1-Ø11	3ØØ.ØØØ		35.ØØØ	2	1	3
Ø1-Ø11	6ØØ.ØØØ		45.ØØØ	2	9	36
Ø1-Ø11	35Ø.ØØØ		7Ø.ØØØ	2	5	23
Ø1-Ø11	15Ø.ØØØ		28.ØØØ	2	84	187
Ø1-Ø11	28Ø.ØØØ		4Ø.ØØØ	2	34	122
Ø1-Ø11	6ØØ.ØØØ		25.ØØØ	2	6	14
Ø1-Ø11	25Ø.ØØØ		58.ØØØ	2	8	14
Ø1-Ø11	15Ø.ØØØ		4Ø.ØØØ	2	9	3Ø
Ø1-Ø11	85Ø.ØØØ		2Ø.ØØØ	2	2	8
Ø1-Ø11	15Ø.ØØØ		58.5ØØ	2	3	11
Ø1-Ø11	85.ØØØ		12Ø.ØØØ	2	4	16
Ø1-Ø11	35.ØØØ		17.ØØØ	2	6	6
Ø1-Ø11	1Ø.ØØØ		2Ø.ØØØ	2	4	5
Ø1-Ø11	6ØØ.ØØØ		33.4ØØ	2	6	14
Ø1-Ø11	2Ø.ØØØ		6Ø.ØØØ	2	3	7

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø11	6ØØ.ØØØ		29.8ØØ	2	5Ø	97
Ø1-Ø11	3ØØ.ØØØ		1ØØ.ØØØ	2	3	5
Ø1-Ø11	1ØØ.ØØØ		66.ØØØ	2	3	4
Ø1-Ø11	15.ØØØ		7Ø.ØØØ	2	7	7
Ø1-Ø11	4Ø.ØØØ		4Ø.ØØØ	2	3	5
Ø1-Ø11	225.ØØØ		1ØØ.ØØØ	2	13	26
Ø1-Ø11	13Ø.ØØØ		1ØØ.ØØØ	2	44	88
Ø1-Ø11	75.ØØØ		4Ø.ØØØ	2	1	5
Ø1-Ø11	45Ø.ØØØ		7Ø.ØØØ	2	25	118
Ø1-Ø11	8Ø.ØØØ		1ØØ.ØØØ	2	44	89
Ø1-Ø11	9ØØ.ØØØ		3Ø.ØØØ	2	3	11
Ø1-Ø11	1Ø.ØØØ		78.ØØØ	2	14	54
Ø1-Ø11	125.ØØØ		25.ØØØ	2	1	4
Ø1-Ø14	1Ø.ØØØ		25.ØØØ	2	1	3
Ø1-Ø14	Ø.ØØØ	4.5ØØ	375.ØØØ	2	9	122
Ø1-Ø14	2.5ØØ		45Ø.ØØØ	2	71	87
Ø1-Ø14	4.ØØØ		15.ØØØ	2	6	6
Ø1-Ø14	8.ØØØ		15.ØØØ	2	3	12
Ø1-Ø14	7.ØØØ		1Ø.ØØØ	2	9	15
Ø1-Ø14	1Ø.ØØØ		2Ø.ØØØ	2	6	12
Ø1-Ø14	1Ø.ØØØ		5.ØØØ	2	1Ø	23
Ø1-Ø14	Ø.5ØØ		75Ø.ØØØ	2	7	16
Ø1-Ø14	1Ø.ØØØ		1Ø.ØØØ	2	5	12
Ø1-Ø14	3.8ØØ		1ØØ.ØØØ	2	3	5
Ø1-Ø14	Ø.ØØØ	1.Ø8Ø	1,5ØØ.ØØØ	2	2Ø	1Ø9
Ø1-Ø14	1.42Ø		9ØØ.ØØØ	2	1	153
Ø1-Ø14	6.ØØØ		22.ØØØ	2	13	51
Ø1-Ø14	5.ØØØ		1Ø.ØØØ	2	7	15
Ø1-Ø14	Ø.ØØØ	Ø.66Ø	3,ØØØ.ØØØ	2	11	111
Ø1-Ø17	75.ØØØ		75.ØØØ	2	6	48
Ø1-Ø17	1ØØ.ØØØ		41.ØØØ	2	23	48
Ø1-Ø17	1ØØ.ØØØ		7Ø.ØØØ	2	2	12
Ø1-Ø17	4Ø.ØØØ		9Ø.ØØØ	2	7	23
Ø1-Ø17	25.ØØØ		76.ØØØ	2	4	5
Ø1-Ø17	325.ØØØ		44.ØØØ	2	12	48
Ø1-Ø17	1.5ØØ		13.5ØØ	2	39	39
Ø1-Ø17	1,15Ø.ØØØ		24.ØØØ	2	1	8
Ø1-Ø17	715.ØØØ		45.ØØØ	2	6	36
Ø1-Ø17	4.ØØØ		35.ØØØ	2	2	4
Ø1-Ø17	1Ø.ØØØ		4Ø.ØØØ	2	1	2
Ø1-Ø17	7.5ØØ		22.ØØØ	2	11	25
Ø1-Ø17	1.ØØØ		25.ØØØ	2	1	2
Ø1-Ø17	1ØØ.ØØØ		55.ØØØ	2	6	24
Ø1-Ø17	2Ø.ØØØ		3Ø.ØØØ	2	1	2
Ø1-Ø17	14Ø.ØØØ		2Ø.22Ø	2	3	7
Ø1-Ø17	48Ø.ØØØ		65.ØØØ	2	25	149
Ø1-Ø17	2.ØØØ		33.4ØØ	2	31	31

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø17	15.ØØØ		41.ØØØ	2	15	33
Ø1-Ø17	3Ø.ØØØ		6Ø.ØØØ	2	44	132
Ø1-Ø17	5Ø.ØØØ		35.ØØØ	2	3	5
Ø1-Ø17	3Ø.ØØØ		75.ØØØ	2	7	23
Ø1-Ø17	225.ØØØ		42.5ØØ	2	14	56
Ø1-Ø17	3Ø.ØØØ		85.ØØØ	2	13	39
Ø1-Ø17	375.ØØØ		7Ø.ØØØ	2	3	36
Ø1-Ø17	25.ØØØ		35.ØØØ	2	3	1Ø
Ø1-Ø17	85.ØØØ		1ØØ.ØØØ	2	2	2
Ø1-Ø17	25.ØØØ		25.5ØØ	2	31	31
Ø1-Ø17	85.ØØØ		75.ØØØ	2	6	1Ø
Ø1-Ø17	5Ø.ØØØ		65.ØØØ	2	2	8
Ø1-Ø17	24Ø.ØØØ		65.ØØØ	2	6	16
Ø1-Ø17	25.ØØØ		7Ø.ØØØ	2	6	15
Ø1-Ø17	49Ø.ØØØ		65.ØØØ	2	28	173
Ø1-Ø17	43Ø.ØØØ		6Ø.ØØØ	2	28	11Ø
Ø1-Ø17	15.ØØØ		4Ø.ØØØ	2	2	3
Ø1-Ø17	43Ø.ØØØ		65.ØØØ	2	44	131
Ø1-Ø17	36Ø.ØØØ		35.ØØØ	2	4	13
Ø1-Ø17	1ØØ.ØØØ		34.1ØØ	2	3	5
Ø1-Ø17	53Ø.ØØØ		13Ø.ØØØ	2	6	24
Ø1-Ø17	148.ØØØ		28.ØØØ	2	9	2Ø
Ø1-Ø17	25Ø.ØØØ		3Ø.ØØØ	2	3	9
Ø1-Ø17	5Ø.ØØØ		62.ØØØ	2	4	21
Ø1-Ø17	15.ØØØ		27.ØØØ	2	43	43
Ø1-Ø17	3Ø.ØØØ		58.ØØØ	2	14	32
Ø1-Ø17	255.ØØØ		34.ØØØ	2	44	165
Ø1-Ø17	1.5ØØ		28.9ØØ	2	41	43
Ø1-Ø17	1Ø.ØØØ		81.ØØØ	2	5	1Ø
Ø1-Ø17	4Ø.ØØØ		5Ø.ØØØ	2	14	32
Ø1-Ø17	65.ØØØ		75.ØØØ	2	1	5
Ø1-Ø17	4Ø.ØØØ		45.ØØØ	2	45	93
Ø1-Ø17	1Ø.ØØØ		5Ø.ØØØ	2	59	119
Ø1-Ø17	2.ØØØ		51.9ØØ	2	42	43
Ø1-Ø17	285.ØØØ		6Ø.ØØØ	2	44	88
Ø1-Ø17	25.ØØØ		75.ØØØ	2	7	12
Ø1-Ø17	1Ø.ØØØ		31.ØØØ	2	2Ø	38
Ø1-Ø17	45.ØØØ		22.ØØØ	2	3	12
Ø1-Ø17	3ØØ.ØØØ		29.ØØØ	2	8	3Ø
Ø1-Ø17	165.ØØØ		69.6ØØ	2	6	24
Ø1-Ø17	1,14Ø.ØØØ		34.ØØØ	2	4	4
Ø1-Ø17	25.ØØØ		4Ø.ØØØ	2	3	6
Ø1-Ø17	32Ø.ØØØ		6Ø.ØØØ	2	16	33
Ø1-Ø18	6Ø.ØØØ		43.ØØØ	2	3	6
Ø1-Ø18	3Ø.ØØØ		3Ø.ØØØ	2	2	4
Ø1-Ø18	5Ø.ØØØ		35.ØØØ	2	5	11
Ø1-Ø18	3Ø.ØØØ		22.ØØØ	2	2	3

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø18	2Ø.ØØØ		5Ø.ØØØ	2	2	4
Ø1-Ø18	1,ØØØ.ØØØ		25.ØØØ	2	3	9
Ø1-Ø18	4ØØ.ØØØ		3Ø.ØØØ	2	6	12
Ø1-Ø18	32Ø.ØØØ		6Ø.ØØØ	2	44	87
Ø1-Ø18	6.ØØØ		15.ØØØ	2	2	8
Ø1-Ø18	4ØØ.ØØØ		15.ØØØ	2	8	14
Ø1-Ø18	65.ØØØ		63.ØØØ	2	32	58
Ø1-Ø18	1Ø.ØØØ		9Ø.ØØØ	2	2	3
Ø1-Ø18	26Ø.ØØØ		7Ø.ØØØ	2	4	9
Ø1-Ø18	55Ø.ØØØ		1Ø.ØØØ	2	15	32
Ø1-Ø18	625.ØØØ		7Ø.ØØØ	2	1	8
Ø1-Ø18	25.ØØØ		5Ø.ØØØ	2	46	184
Ø1-Ø18	4ØØ.ØØØ		13.ØØØ	2	1	2
Ø1-Ø18	75.ØØØ		55.ØØØ	2	2	4
Ø1-Ø18	6Ø.ØØØ		5Ø.ØØØ	2	2	6
Ø1-Ø18	9ØØ.ØØØ		1Ø.ØØØ	2	1	2
Ø1-Ø18	6Ø.ØØØ		8Ø.ØØØ	2	21	61
Ø1-Ø18	275.ØØØ		75.ØØØ	2	2	2
Ø1-Ø18	25Ø.ØØØ		1ØØ.ØØØ	2	6	14
Ø1-Ø18	485.ØØØ		4Ø.ØØØ	2	1Ø	19
Ø1-Ø18	3,ØØØ.ØØØ		1Ø.25Ø	2	6	36
Ø1-Ø18	155.ØØØ		9Ø.ØØØ	2	3Ø	3Ø
Ø1-Ø18	25.ØØØ		4Ø.ØØØ	2	1	6
Ø1-Ø18	125.ØØØ		1ØØ.ØØØ	2	4	1Ø
Ø1-Ø18	82Ø.ØØØ		3Ø.ØØØ	2	2	5
Ø1-Ø18	7ØØ.ØØØ		15.ØØØ	2	4	11
Ø1-Ø18	35.ØØØ		85.ØØØ	2	1	8
Ø1-Ø18	2,5ØØ.ØØØ		13.ØØØ	2	2	9
Ø1-Ø18	2ØØ.ØØØ		6Ø.ØØØ	2	2	4
Ø1-Ø18	21.ØØØ		84.ØØØ	2	5	11
Ø1-Ø18	8Ø.ØØØ		5Ø.ØØØ	2	3	8
Ø1-Ø18	1,12Ø.ØØØ		15.ØØØ	2	9	33
Ø1-Ø18	2ØØ.ØØØ		35.ØØØ	2	2	6
Ø1-Ø18	1ØØ.ØØØ		125.ØØØ	2	3	6
Ø1-Ø18	15.ØØØ		35.ØØØ	2	3	6
Ø1-Ø18	22.ØØØ		65.ØØØ	2	3	13
Ø1-Ø18	6Ø.ØØØ		6Ø.ØØØ	2	9	22
Ø1-Ø18	7ØØ.ØØØ		34.ØØØ	2	1	3
Ø1-Ø18	11Ø.ØØØ		56.ØØØ	2	3	4
Ø1-Ø18	5.ØØØ		15.ØØØ	2	5	19
Ø1-Ø18	25Ø.ØØØ		5Ø.ØØØ	2	2	3
Ø1-Ø18	1Ø.ØØØ		25.ØØØ	2	6	6
Ø1-Ø18	45Ø.ØØØ		35.ØØØ	2	4	7
Ø1-Ø18	2ØØ.ØØØ		9Ø.ØØØ	2	4	16
Ø1-Ø18	4Ø.ØØØ		6Ø.ØØØ	2	5	1Ø
Ø1-Ø18	1ØØ.ØØØ		75.ØØØ	2	3	12
Ø1-Ø18	27Ø.ØØØ		25.ØØØ	2	49	99

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø18	75.ØØØ		75.ØØØ	2	3	1Ø
Ø1-Ø18	15.ØØØ		3Ø.ØØØ	2	5	1Ø
Ø1-Ø18	175.ØØØ		36.ØØØ	2	2	12
Ø1-Ø18	21Ø.ØØØ		75.ØØØ	2	3	16
Ø1-Ø18	5.ØØØ		5.ØØØ	2	3	18
Ø1-Ø18	125.ØØØ		65.ØØØ	2	4	7
Ø1-Ø18	1ØØ.ØØØ		15.ØØØ	2	4	4
Ø1-Ø18	11Ø.ØØØ		115.ØØØ	2	6	12
Ø1-Ø18	25Ø.ØØØ		34.ØØØ	2	3	5
Ø1-Ø18	1,8ØØ.ØØØ		15.ØØØ	2	9	38
Ø1-Ø18	175.ØØØ		32.ØØØ	2	1	4
Ø1-Ø19	1Ø.ØØØ		3Ø.ØØØ	2	4	18
Ø1-Ø19	4.ØØØ		1Ø8.ØØØ	2	11	17
Ø1-Ø19	4.ØØØ		6Ø.ØØØ	2	1	3
Ø1-Ø28	25Ø.ØØØ		76Ø.ØØØ	2	3	8
Ø1-Ø34	Ø.3ØØ		4,5ØØ.ØØØ	2	13	28
Ø1-Ø35	875.ØØØ		1ØØ.ØØØ	2	9	18
Ø1-Ø35	3,ØØØ.ØØØ		15Ø.ØØØ	2	2	12
Ø1-Ø35	6,ØØØ.ØØØ		15Ø.ØØØ	2	2	6
Ø1-Ø37	Ø.3ØØ		4,5ØØ.ØØØ	2	9	14
Ø1-Ø38	4.ØØØ		6,ØØØ.ØØØ	2	4	18
Ø1-Ø38	18Ø.ØØØ		72.ØØØ	2	16	26
Ø1-Ø38	4Ø.ØØØ		6Ø.ØØØ	2	3	5
Ø1-Ø38	38.ØØØ		3Ø.ØØØ	2	4	4
Ø1-ØØ1	555.ØØØ		1,35Ø.ØØØ	3	4	48
Ø1-ØØ2	7ØØ.ØØØ		1ØØ.ØØØ	3	1	6
Ø1-ØØ2	2ØØ.ØØØ		76Ø.ØØØ	3	15	14
Ø1-ØØ2	2ØØ.ØØØ		8ØØ.ØØØ	3	3Ø	35
Ø1-ØØ2	2ØØ.ØØØ		125.ØØØ	3	1Ø	21
Ø1-ØØ3	3,2ØØ.ØØØ		16.ØØØ	3	2	6
Ø1-ØØ5	1Ø.ØØØ		5Ø.ØØØ	3	49	5Ø
Ø1-ØØ5	15.ØØØ		1,1ØØ.ØØØ	3	5Ø	118
Ø1-ØØ5	38.ØØØ		3,ØØØ.ØØØ	3	4Ø	169
Ø1-ØØ5	25Ø.ØØØ		15Ø.ØØØ	3	27	58
Ø1-ØØ5	415.ØØØ		5Ø.ØØØ	3	9	28
Ø1-ØØ5	75Ø.ØØØ		55.ØØØ	3	35	97
Ø1-ØØ5	9ØØ.ØØØ		5Ø.ØØØ	3	1	3
Ø1-ØØ5	55.ØØØ		9Ø.ØØØ	3	18	78
Ø1-ØØ7	5Ø.ØØØ		1ØØ.ØØØ	3	6	8
Ø1-ØØ7	25.ØØØ		25.ØØØ	3	1Ø	15
Ø1-ØØ7	2ØØ.ØØØ		1ØØ.ØØØ	3	7	1Ø
Ø1-ØØ7	5Ø.ØØØ		5Ø.ØØØ	3	3	9
Ø1-ØØ7	6.ØØØ		18.ØØØ	3	13	51
Ø1-ØØ8	25.ØØØ		5Ø.ØØØ	3	21	56
Ø1-ØØ8	1Ø.ØØØ		32.5ØØ	3	112	111
Ø1-ØØ9	5.ØØØ		2,ØØØ.ØØØ	3	16	57
Ø1-ØØ9	5.ØØØ		1,ØØØ.ØØØ	3	8	14

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-ØØ9	15.ØØØ		5Ø.ØØØ	3	52	95
Ø1-ØØ9	6Ø.ØØØ		19Ø.ØØØ	3	6	56
Ø1-ØØ9	65.ØØØ		175.ØØØ	3	68	393
Ø1-ØØ9	11.ØØØ		1,ØØØ.ØØØ	3	12	15
Ø1-ØØ9	8.ØØØ		2,ØØØ.ØØØ	3	15	31
Ø1-ØØ9	1Ø.ØØØ		1,ØØØ.ØØØ	3	2	5
Ø1-Ø1Ø	29.ØØØ		3,ØØØ.ØØØ	3	7	42
Ø1-Ø1Ø	58.7ØØ		3,ØØØ.ØØØ	3	11	22
Ø1-Ø1Ø	12Ø.ØØØ		3,ØØØ.ØØØ	3	4	16
Ø1-Ø1Ø	2Ø.ØØØ		5,ØØØ.ØØØ	3	5	8
Ø1-Ø1Ø	88.ØØØ		4,5ØØ.ØØØ	3	7	6
Ø1-Ø1Ø	114.ØØØ		3,ØØØ.ØØØ	3	4	9
Ø1-Ø1Ø	3Ø3.ØØØ		3,ØØØ.ØØØ	3	2	7
Ø1-Ø1Ø	12Ø.ØØØ		5,ØØØ.ØØØ	3	8	41
Ø1-Ø1Ø	1Ø.ØØØ		1,5ØØ.ØØØ	3	8	28
Ø1-Ø11	4ØØ.ØØØ		2Ø.ØØØ	3	1	6
Ø1-Ø11	5ØØ.ØØØ		1ØØ.ØØØ	3	16	22
Ø1-Ø11	4Ø.ØØØ		7.5ØØ	3	7	1Ø
Ø1-Ø11	35.ØØØ		35.ØØØ	3	12	31
Ø1-Ø11	5Ø.ØØØ		3Ø.ØØØ	3	4	11
Ø1-Ø11	1Ø.ØØØ		4.ØØØ	3	1Ø	32
Ø1-Ø11	7Ø.ØØØ		15Ø.ØØØ	3	4	12
Ø1-Ø11	4ØØ.ØØØ		4Ø.ØØØ	3	5Ø	219
Ø1-Ø11	15.ØØØ		3Ø.ØØØ	3	1	9
Ø1-Ø11	2,ØØØ.ØØØ		15Ø.ØØØ	3	8	18
Ø1-Ø11	5ØØ.ØØØ		5Ø.ØØØ	3	23	48
Ø1-Ø11	3ØØ.ØØØ		75.ØØØ	3	3	6
Ø1-Ø11	6ØØ.ØØØ		34.ØØØ	3	6	12
Ø1-Ø11	18Ø.ØØØ		6Ø.ØØØ	3	5	1Ø
Ø1-Ø11	55.ØØØ		23.ØØØ	3	3Ø9	39Ø
Ø1-Ø11	3ØØ.ØØØ		25.ØØØ	3	5	1Ø
Ø1-Ø11	4ØØ.ØØØ		121.ØØØ	3	1	3
Ø1-Ø11	1,ØØØ.ØØØ		147.ØØØ	3	14	41
Ø1-Ø11	8ØØ.ØØØ		5Ø.ØØØ	3	1Ø	26
Ø1-Ø11	1,35Ø.ØØØ		1ØØ.ØØØ	3	4	1Ø
Ø1-Ø11	1,575.ØØØ		25.ØØØ	3	4	28
Ø1-Ø11	2Ø.ØØØ		2Ø.ØØØ	3	83	115
Ø1-Ø11	1Ø.ØØØ		4Ø.ØØØ	3	47	99
Ø1-Ø11	5ØØ.ØØØ		2Ø.ØØØ	3	2	6
Ø1-Ø11	1,1ØØ.ØØØ		336.ØØØ	3	18	1Ø1
Ø1-Ø11	5Ø.ØØØ		5Ø.ØØØ	3	7	11
Ø1-Ø11	63Ø.ØØØ		55.ØØØ	3	1Ø	1Ø
Ø1-Ø11	4ØØ.ØØØ		125.ØØØ	3	1	6
Ø1-Ø11	25Ø.ØØØ		1ØØ.ØØØ	3	4	7
Ø1-Ø11	5Ø.ØØØ		22.ØØØ	3	11	25
Ø1-Ø11	55Ø.ØØØ		3Ø.ØØØ	3	4	14
Ø1-Ø11	35Ø.ØØØ		3Ø.ØØØ	3	2	7

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø11	4ØØ.ØØØ		45.ØØØ	3	2	41
Ø1-Ø11	12.ØØØ		35.ØØØ	3	4Ø	41
Ø1-Ø11	15Ø.ØØØ		9Ø.ØØØ	3	36	76
Ø1-Ø11	2,2ØØ.ØØØ		4Ø.ØØØ	3	3	4
Ø1-Ø11	4Ø.ØØØ		2Ø.ØØØ	3	8	8
Ø1-Ø11	2ØØ.ØØØ		5Ø.ØØØ	3	17	38
Ø1-Ø11	15Ø.ØØØ		25.ØØØ	3	21	37
Ø1-Ø11	25.ØØØ		6Ø.ØØØ	3	4	9
Ø1-Ø14	15.ØØØ		25.ØØØ	3	24	47
Ø1-Ø14	3Ø.ØØØ		22.ØØØ	3	7	11
Ø1-Ø14	Ø.ØØØ	4.5ØØ	325.ØØØ	3	3	31
Ø1-Ø14	6.ØØØ		15.ØØØ	3	2Ø	51
Ø1-Ø14	Ø.ØØØ	1.25Ø	1,5ØØ.ØØØ	3	25	72
Ø1-Ø14	14.ØØØ		15.ØØØ	3	16	54
Ø1-Ø14	5.ØØØ		22.ØØØ	3	124	923
Ø1-Ø14	5.ØØØ		2Ø.ØØØ	3	17	119
Ø1-Ø17	7ØØ.ØØØ		5Ø.ØØØ	3	2	14
Ø1-Ø17	8.ØØØ		5Ø.ØØØ	3	29	57
Ø1-Ø17	8.ØØØ		42.ØØØ	3	44	44
Ø1-Ø17	1Ø.ØØØ		22.ØØØ	3	3	6
Ø1-Ø17	63Ø.ØØØ		65.ØØØ	3	18	37
Ø1-Ø17	15.ØØØ		7Ø.ØØØ	3	22	46
Ø1-Ø17	325.ØØØ		8Ø.ØØØ	3	8	17
Ø1-Ø17	15Ø.ØØØ		85.ØØØ	3	7	22
Ø1-Ø17	2.ØØØ		25.ØØØ	3	51	51
Ø1-Ø17	8.ØØØ		41.ØØØ	3	32	32
Ø1-Ø17	25Ø.ØØØ		41.ØØØ	3	4	18
Ø1-Ø17	25.ØØØ		3Ø.ØØØ	3	15	28
Ø1-Ø17	72Ø.ØØØ		9Ø.ØØØ	3	5	8Ø
Ø1-Ø17	6Ø.ØØØ		7Ø.ØØØ	3	22	53
Ø1-Ø17	5Ø.ØØØ		5Ø.ØØØ	3	4	8
Ø1-Ø17	1Ø.ØØØ		35.ØØØ	3	1Ø	22
Ø1-Ø17	1ØØ.ØØØ		34.ØØØ	3	3	8
Ø1-Ø17	15.ØØØ		75.ØØØ	3	13	27
Ø1-Ø17	17.ØØØ		55.ØØØ	3	5	9
Ø1-Ø18	7Ø.ØØØ		5Ø.ØØØ	3	26	54
Ø1-Ø18	1ØØ.ØØØ		43.ØØØ	3	5	11
Ø1-Ø18	18Ø.ØØØ		72.ØØØ	3	33	48
Ø1-Ø18	15Ø.ØØØ		6Ø.ØØØ	3	2	7
Ø1-Ø18	45Ø.ØØØ		5Ø.ØØØ	3	13	3Ø
Ø1-Ø18	5Ø.ØØØ		6Ø.ØØØ	3	26	59
Ø1-Ø18	5ØØ.ØØØ		35.ØØØ	3	8	32
Ø1-Ø18	15Ø.ØØØ		65.ØØØ	3	12	22
Ø1-Ø18	4Ø.ØØØ		2Ø.ØØØ	3	5Ø	5Ø
Ø1-Ø18	175.ØØØ		5Ø.ØØØ	3	1Ø	1Ø
Ø1-Ø18	1Ø.ØØØ		95.ØØØ	3	6	19
Ø1-Ø18	2ØØ.ØØØ		1ØØ.ØØØ	3	5	15

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø18	125.ØØØ		6Ø.ØØØ	3	12	24
Ø1-Ø18	5Ø.ØØØ		48.ØØØ	3	2	3
Ø1-Ø18	115.ØØØ		5Ø.ØØØ	3	7	14
Ø1-Ø18	1Ø.ØØØ		5Ø.ØØØ	3	4	1Ø
Ø1-ØØ1	25Ø.ØØØ		76Ø.ØØØ	4	13	37
Ø1-ØØ1	3ØØ.ØØØ		471.ØØØ	4	11	38
Ø1-ØØ2	5Ø.ØØØ		5Ø.ØØØ	4	1Ø	14
Ø1-ØØ3	4,9ØØ.ØØØ		24.ØØØ	4	6	12
Ø1-ØØ3	5,6ØØ.ØØØ		19.ØØØ	4	5	14
Ø1-ØØ5	18.ØØØ		1,3ØØ.ØØØ	4	49	117
Ø1-ØØ5	6Ø.ØØØ		1ØØ.ØØØ	4	2Ø	88
Ø1-ØØ5	8Ø.ØØØ		1,14Ø.ØØØ	4	31	133
Ø1-ØØ5	5ØØ.ØØØ		15Ø.ØØØ	4	47	1151
Ø1-ØØ5	375.ØØØ		5Ø.ØØØ	4	33	66
Ø1-ØØ5	7ØØ.ØØØ		6Ø.ØØØ	4	54	194
Ø1-ØØ5	15.ØØØ		35Ø.ØØØ	4	53	68
Ø1-ØØ8	22.ØØØ		5Ø.ØØØ	4	2Ø	197
Ø1-ØØ9	4ØØ.ØØØ		15Ø.ØØØ	4	14	45
Ø1-ØØ9	6Ø.ØØØ		5Ø.ØØØ	4	49	148
Ø1-ØØ9	25.ØØØ		25.ØØØ	4	79	87
Ø1-Ø1Ø	2Ø.ØØØ		2,ØØØ.ØØØ	4	7	29
Ø1-Ø1Ø	45.ØØØ		1,5ØØ.ØØØ	4	2	7
Ø1-Ø1Ø	11Ø.ØØØ		1,775.ØØØ	4	1Ø	58
Ø1-Ø1Ø	2Ø.ØØØ		1,5ØØ.ØØØ	4	25	34
Ø1-Ø1Ø	15.ØØØ		3,ØØØ.ØØØ	4	23	5Ø
Ø1-Ø11	1ØØ.ØØØ		15Ø.ØØØ	4	16	48
Ø1-Ø11	22Ø.ØØØ		9Ø.ØØØ	4	13	3Ø
Ø1-Ø11	1ØØ.ØØØ		24.ØØØ	4	5	2Ø
Ø1-Ø11	155.ØØØ		1ØØ.ØØØ	4	19	19
Ø1-Ø11	2ØØ.ØØØ		35.ØØØ	4	12	25
Ø1-Ø11	3Ø.ØØØ		6Ø.ØØØ	4	9	22
Ø1-Ø11	4ØØ.ØØØ		36.ØØØ	4	5	2Ø
Ø1-Ø11	1,ØØØ.ØØØ		146.ØØØ	4	11	29
Ø1-Ø11	2ØØ.ØØØ		7Ø.ØØØ	4	15	54
Ø1-Ø11	3ØØ.ØØØ		125.ØØØ	4	7	14
Ø1-Ø11	1ØØ.ØØØ		1ØØ.ØØØ	4	4	6
Ø1-Ø11	6ØØ.ØØØ		3Ø.ØØØ	4	21	49
Ø1-Ø11	65Ø.ØØØ		8Ø.ØØØ	4	8	58
Ø1-Ø11	1Ø.ØØØ		25.ØØØ	4	2	5
Ø1-Ø11	2Ø.ØØØ		5Ø.ØØØ	4	25	28
Ø1-Ø11	28.ØØØ		51.ØØØ	4	82	192
Ø1-Ø11	75Ø.ØØØ		125.ØØØ	4	5	6
Ø1-Ø11	5Ø.ØØØ		65.ØØØ	4	235	442
Ø1-Ø11	5ØØ.ØØØ		146.ØØØ	4	7	13
Ø1-Ø11	3Ø.ØØØ		15.ØØØ	4	6	12
Ø1-Ø14	1Ø.ØØØ		26.ØØØ	4	11	13
Ø1-Ø14	5.ØØØ		15.ØØØ	4	117	167

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø14	Ø.85Ø		5ØØ.ØØØ	4	22	84
Ø1-Ø17	4Ø.ØØØ		7Ø.ØØØ	4	5Ø	2Ø4
Ø1-Ø17	52Ø.ØØØ		65.ØØØ	4	5	26
Ø1-Ø17	18.ØØØ		4Ø.ØØØ	4	28	57
Ø1-Ø17	165.ØØØ		7Ø.ØØØ	4	2Ø	82
Ø1-Ø17	35.ØØØ		75.ØØØ	4	11	4Ø
Ø1-Ø17	1ØØ.ØØØ		35.ØØØ	4	3	6
Ø1-Ø17	3.5ØØ		37.3ØØ	4	34	34
Ø1-Ø17	15.ØØØ		5Ø.ØØØ	4	11	24
Ø1-Ø18	15Ø.ØØØ		5Ø.ØØØ	4	4	12
Ø1-Ø18	1Ø.ØØØ		15.ØØØ	4	9	33
Ø1-Ø18	17Ø.ØØØ		45.ØØØ	4	89	174
Ø1-Ø18	15.ØØØ		5Ø.ØØØ	4	49	53
Ø1-Ø18	1ØØ.ØØØ		13Ø.ØØØ	4	22	43
Ø1-Ø18	12.ØØØ		5Ø.ØØØ	4	9	17
Ø1-Ø18	15.ØØØ		25.ØØØ	4	2Ø	23
Ø1-Ø18	16Ø.ØØØ		5Ø.ØØØ	4	26	72
Ø1-Ø18	2ØØ.ØØØ		3Ø.ØØØ	4	19	37
Ø1-Ø18	9ØØ.ØØØ		2Ø.ØØØ	4	7	14
Ø1-Ø18	2,2ØØ.ØØØ		1Ø.ØØØ	4	3	32
Ø1-Ø18	2,2ØØ.ØØØ		12.ØØØ	4	5	12
Ø1-Ø18	2ØØ.ØØØ		7Ø.ØØØ	4	9	17
Ø1-Ø18	125.ØØØ		35.ØØØ	4	5	1Ø
Ø1-Ø18	15.ØØØ		4Ø.ØØØ	4	37	39
Ø1-Ø18	4Ø.ØØØ		4Ø.ØØØ	4	33	66
Ø1-Ø42	25Ø.ØØØ		1ØØ.ØØØ	4	5Ø7	1948
Ø1-ØØ1	3ØØ.ØØØ		476.ØØØ	5	23	85
Ø1-ØØ5	25.ØØØ		5Ø.ØØØ	5	26	48
Ø1-ØØ5	4ØØ.ØØØ		55.ØØØ	5	28	58
Ø1-ØØ5	7ØØ.ØØØ		15Ø.ØØØ	5	15	59
Ø1-ØØ5	35.ØØØ		4ØØ.ØØØ	5	25	54
Ø1-ØØ5	1ØØ.ØØØ		5Ø.ØØØ	5	69	118
Ø1-ØØ5	65Ø.ØØØ		5Ø.ØØØ	5	4	15
Ø1-ØØ9	5Ø.ØØØ		15.ØØØ	5	11	34
Ø1-ØØ9	5Ø.ØØØ		9Ø.ØØØ	5	59	1Ø8
Ø1-ØØ9	1ØØ.ØØØ		5Ø.ØØØ	5	64	76
Ø1-Ø1Ø	2Ø.ØØØ		3,ØØØ.ØØØ	5	22	43
Ø1-Ø1Ø	11Ø.ØØØ		3,ØØØ.ØØØ	5	55	1Ø8
Ø1-Ø1Ø	15.ØØØ		1,5ØØ.ØØØ	5	31	39
Ø1-Ø1Ø	9Ø.ØØØ		2,ØØØ.ØØØ	5	12	49
Ø1-Ø1Ø	2Ø2.ØØØ		2,ØØØ.ØØØ	5	7	24
Ø1-Ø11	3,ØØØ.ØØØ		15Ø.ØØØ	5	6	47
Ø1-Ø11	5.ØØØ		5.ØØØ	5	83	334
Ø1-Ø11	2Ø.ØØØ		3Ø.ØØØ	5	15	29
Ø1-Ø11	25.ØØØ		5Ø.ØØØ	5	6	12
Ø1-Ø11	57.ØØØ		5Ø.ØØØ	5	32	66
Ø1-Ø11	8Ø.ØØØ		5.ØØØ	5	247	573

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-Ø11	15.ØØØ		4Ø.ØØØ	5	44	56
Ø1-Ø11	6ØØ.ØØØ		1ØØ.ØØØ	5	4	29
Ø1-Ø11	1Ø.ØØØ		5Ø.ØØØ	5	1Ø	22
Ø1-Ø11	1ØØ.ØØØ		5Ø.ØØØ	5	68	119
Ø1-Ø11	5Ø.ØØØ		4Ø.ØØØ	5	142	329
Ø1-Ø14	3Ø.ØØØ		15.ØØØ	5	32	63
Ø1-Ø14	1.56Ø		3ØØ.ØØØ	5	12	34
Ø1-Ø17	2Ø.ØØØ		22.ØØØ	5	5	9
Ø1-Ø17	28Ø.ØØØ		3Ø.ØØØ	5	17	51
Ø1-Ø17	5Ø.ØØØ		55.ØØØ	5	6	28
Ø1-Ø17	595.ØØØ		65.ØØØ	5	7	56
Ø1-Ø18	5ØØ.ØØØ		5Ø.ØØØ	5	6Ø	157
Ø1-Ø18	5Ø.ØØØ		5Ø.ØØØ	5	4	1Ø
Ø1-Ø18	75.ØØØ		6Ø.ØØØ	5	19	81
Ø1-Ø18	1ØØ.ØØØ		7Ø.ØØØ	5	15	33
Ø1-Ø18	3ØØ.ØØØ		5Ø.ØØØ	5	9	17
Ø1-Ø18	135.ØØØ		3Ø.ØØØ	5	7	11
Ø1-Ø18	2ØØ.ØØØ		5Ø.ØØØ	5	16	26
Ø1-Ø18	4Ø.ØØØ		5Ø.ØØØ	5	11Ø	221
Ø1-ØØ1	3ØØ.ØØØ		468.ØØØ	6	41	168
Ø1-ØØ3	5,3ØØ.ØØØ		19.ØØØ	6	37	77
Ø1-ØØ5	5Ø.ØØØ		5Ø.ØØØ	6	17	47
Ø1-ØØ5	4Ø.ØØØ		3,ØØØ.ØØØ	6	7Ø	293
Ø1-ØØ5	15.ØØØ		25.ØØØ	6	49	58
Ø1-ØØ9	25.ØØØ		5Ø.ØØØ	6	42	57
Ø1-ØØ9	1ØØ.ØØØ		15.ØØØ	6	17	3Ø8
Ø1-ØØ9	5Ø.ØØØ		1ØØ.ØØØ	6	16	42
Ø1-ØØ9	5Ø.ØØØ		6Ø.ØØØ	6	183	441
Ø1-Ø1Ø	122.ØØØ		4,5ØØ.ØØØ	6	16	22
Ø1-Ø1Ø	122.ØØØ		3,5ØØ.ØØØ	6	14	24
Ø1-Ø11	75Ø.ØØØ		5Ø.ØØØ	6	8	22
Ø1-Ø11	6ØØ.ØØØ		6Ø.ØØØ	6	6	23
Ø1-Ø11	4Ø.ØØØ		25.ØØØ	6	21	36
Ø1-Ø11	4ØØ.ØØØ		1ØØ.ØØØ	6	7	15
Ø1-Ø11	15Ø.ØØØ		22.ØØØ	6	26	62
Ø1-Ø14	Ø.ØØØ	Ø.75Ø	3,ØØØ.ØØØ	6	161	1148
Ø1-Ø14	Ø.ØØØ	1.5ØØ	1,5ØØ.ØØØ	6	126	288
Ø1-Ø17	3Ø.ØØØ		35.ØØØ	6	13	19
Ø1-Ø18	75.ØØØ		5Ø.ØØØ	6	12	44
Ø1-Ø18	25.ØØØ		6Ø.ØØØ	6	5	17
Ø1-Ø11	75Ø.ØØØ		15Ø.ØØØ	7	18	39
Ø1-Ø11	6ØØ.ØØØ		75.ØØØ	7	12	26
Ø1-Ø17	24Ø.ØØØ		75.ØØØ	7	16	31
Ø1-Ø17	6Ø.ØØØ		8Ø.ØØØ	7	11	34
Ø1-Ø18	3Ø.ØØØ		5Ø.ØØØ	7	12	31
Ø1-ØØ2	1ØØ.ØØØ		5Ø.ØØØ	8	1Ø1	12Ø
Ø1-ØØ3	5,3ØØ.ØØØ		19.3ØØ	8	36	73

B.1 Potential Duplicate Pump Data

LAPL	Capacity (GPM)	Capacity (CFM/CIM)	Pressure (PSI)	APL's	Ship Pop	Fleet Pop
Ø1-ØØ5	3ØØ.ØØØ		5Ø.ØØØ	8	2Ø	33
Ø1-ØØ7	25.ØØØ		5Ø.ØØØ	8	18	34
Ø1-ØØ9	2ØØ.ØØØ		5Ø.ØØØ	8	67	174
Ø1-ØØ9	2ØØ.ØØØ		1ØØ.ØØØ	8	2Ø	56
Ø1-Ø1Ø	1Ø.ØØØ		3,ØØØ.ØØØ	8	111	181
Ø1-Ø11	25Ø.ØØØ		25.ØØØ	8	44	62
Ø1-Ø11	1,ØØØ.ØØØ		175.ØØØ	8	15	2Ø4
Ø1-Ø11	5ØØ.ØØØ		15Ø.ØØØ	8	23	66
Ø1-Ø11	2,ØØØ.ØØØ		175.ØØØ	8	17	83
Ø1-Ø11	1,ØØØ.ØØØ		125.ØØØ	8	27	56
Ø1-Ø11	1,1ØØ.ØØØ		15Ø.ØØØ	8	17	114
Ø1-Ø11	6ØØ.ØØØ		35.ØØØ	8	1Ø	19
Ø1-Ø2Ø	3,ØØØ.ØØØ		15Ø.ØØØ	8	8	75
Ø1-Ø1Ø	2Ø2.ØØØ		3,ØØØ.ØØØ	9	25	83
Ø1-Ø1Ø	2ØØ.ØØØ		3,ØØØ.ØØØ	9	79	29Ø
Ø1-Ø11	15.ØØØ		25.ØØØ	9	59	65
Ø1-ØØ9	5Ø.ØØØ		75.ØØØ	1Ø	83	169
Ø1-Ø1Ø	88.ØØØ		3,ØØØ.ØØØ	1Ø	58	88
Ø1-ØØ5	4ØØ.ØØØ		5Ø.ØØØ	11	23	53
Ø1-Ø1Ø	45.ØØØ		3,ØØØ.ØØØ	11	29	63
Ø1-Ø1Ø	5.ØØØ		3,ØØØ.ØØØ	12	42	153
Ø1-Ø1Ø	9Ø.ØØØ		3,ØØØ.ØØØ	13	74	252
Ø1-Ø11	9ØØ.ØØØ		125.ØØØ	17	82	3Ø6
Ø1-Ø11	5ØØ.ØØØ		125.ØØØ	18	77	332
Ø1-ØØ9	5Ø.ØØØ		5Ø.ØØØ	22	136	3ØØ
Ø1-Ø1Ø	122.ØØØ		3,ØØØ.ØØØ	34	62	145
Ø1-Ø11	1,ØØØ.ØØØ		15Ø.ØØØ	41	1ØØ	523

B.2 Duplicate Percentages

Equipment Per APL	Frequency	Potential Duplicates
2	447	89
3	121	36
4	69	69
5	4Ø	5Ø
6	21	32
7	5	9
8	15	3Ø
9	3	7
1Ø	2	5
11	2	6
12	1	3
13	1	3
17	1	4
18	1	5
22	1	6
34	1	9
41	1	1Ø
Total Potential Duplicates		373

APPENDIX C : DUPLICATE APL'S AND PARTS

Appendix C provides the estimates of the potential number of duplicates on a commodity basis. The method used to estimate these numbers was described in Chapter III. The tables are presented in two parts. The first part provides the potential duplicate APL's and parts that are currently in the Navy Supply System as well as the number of duplicate equipments and parts entering the Navy inventory in 1987. The second portion of the table provides the data for 1988 and 1989.

Patential Duplicate APL's and Parts

Namenclature	Tatal APL's	Patential Duplicate APL's	Initial Patential Parts Reductian	1987 Patential APL Reductian	1987 Patential Parts Reductian
PUMPS	7,400	373	1,585	24	103
BOILERS	198	10	235	0	9
HEAT EXCHANGERS	1,675	84	169	3	6
CONDENSERS	797	40	90	1	1
TURBINES	905	46	1,289	1	27
COMPRESSORS	808	41	784	3	57
HEATERS	2,523	127	159	9	11
DISTILLING PLANTS	320	16	65	1	2
BATTERY CHANGERS	290	15	55	1	5
METERS	439	22	17	1	1
CONVERTERS	657	33	190	2	12
TRANSFORMERS	878	44	11	0	0
CIRCUIT BREAKERS	3,971	200	500	8	19
CONTROLLERS	11,812	595	2,382	44	178
GENERATORS	704	35	151	4	16
MOTORS	14,014	706	883	49	62
MOTOR GENERATORS	351	18	53	0	1
RELAYS	1,543	78	97	3	4
RHEOSTATS	509	26	32	0	0
SWITCHES	9,260	467	467	23	23
SWITCHBOARDS	2,839	143	537	4	14
VISUAL ALARMS	615	31	46	1	1
LIGHTING FIXTURES	1,035	52	65	2	2
GYRO COMPASSES	806	41	386	1	10
PROJECTION EQUIP	54	3	52	0	2
I/C EQUIP	1,286	65	259	2	9
NAVIGATIONAL EQUIP	322	16	183	2	21
INJECTORS	71	4	23	0	1
BURNERS	109	5	49	0	2
MARINE HARDWARE	1,573	79	159	2	4
REFRIG EQUIP	3,407	172	429	22	55
AIR CONDITIONING	206	10	34	1	4
STARTERS	216	11	82	1	5
WIPERS	178	9	31	0	1
AUDIBLE ALARMS	99	5	12	1	1
BEARINGS	632	32	40	1	1
INDICATORS	2,192	110	276	8	20
CLUTCHES	146	7	35	0	2
FANS	2,292	116	58	5	2
SHOP EQUIP	3,208	162	323	11	22
REGULATORS	884	45	201	1	5
GALLEY EQUIP	2,142	108	351	10	33
DEHYDRATORS	247	12	68	1	4
GAGES	3,252	164	205	7	8
TESTING EQUIP	637	32	128	3	14
FILTERS	3,563	180	449	10	25
PANELS	4,265	215	645	11	34

Patential Ouplicate APL's and Parts

Namenclature	Total APL's	Patential Ouplicate APL's	Initial Potential Parts Reduction	1987 Patential APL Reductian	1987 Patential Parts Reduction
ISOLATORS	20	1	2	Ø	Ø
HYORALIC EQUIP	1,368	69	396	1Ø	57
CAPSTANS	140	7	26	Ø	1
REELS	306	15	50	2	5
DAVITS	191	1Ø	17	Ø	Ø
CRANES	307	15	139	1	5
HOISTS	717	36	172	2	8
ELEVATORS	740	37	242	1	4
STEERING EQUIP	132	7	95	Ø	4
CONTROL EQUIP	6,785	342	1,111	17	56
WINCHES	742	37	243	3	19
WINOLASSES	162	8	71	Ø	2
FIREFIGHTING EQUIP	345	17	83	3	14
LUBRICATORS	253	13	32	1	2
ENGINES	506	26	2,780	2	231
PLUMBING EQUIP	259	13	29	1	1
GEARS ANO REOUCERS	1,349	68	493	3	18
GOVERNORS	390	20	339	3	46
IGNITION EQUIP	4	Ø	1	Ø	Ø
EJECTORS	415	21	78	Ø	1
EDUCTORS	369	19	9	Ø	Ø
STRAINERS	4,191	211	158	5	4
PURIFIERS	267	13	316	1	31
TRAPS-STEAM	1,014	51	51	1	1
COUPLINGS	942	47	47	4	4
SILENCING EQUIP	161	8	6	Ø	Ø
BRAKES	828	42	63	2	3
BLOWERS	240	12	148	Ø	6
WELOING SYSTEMS	367	18	88	2	9
BOAT PROPULSION	909	46	80	1	2
OECK MACHINERY	1,663	84	231	2	7
PHOTOGRAPHIC EQUIP	72	4	11	Ø	Ø
UNOERWATER LOG EQUIP	207	1Ø	78	Ø	1
VALVES	59,254	2,987	4,480	99	149
MISC PARTS	2,398	121	1,934	11	183
LAUNORY EQUIP	561	28	198	12	86
TANKS	764	39	48	1	1
PIPE, HOSE, & FITTINGS	139	7	7	Ø	Ø
ASW EQUIP	70	4	46	1	7
YELLOW GEAR	1,787	90	225	61	152
PERISCOPES	361	18	150	Ø	2
MISC EQUIP	1,706	86	150	3	5
GRANO TOTALS	188,731	9,513	29,268	541	1,968

Nomencloture	1988 Potential APL Reduction	1988 Potential Ports Reduction	1989 Potential APL Reduction	1989 Potential Ports Reduction
PUMPS	24	103	24	103
BOILERS	0	9	0	9
HEAT EXCHANGERS	3	6	3	6
CONDENSERS	1	1	1	1
TURBINES	1	27	1	27
COMPRESSORS	3	57	3	57
HEATERS	9	11	9	11
DISTILLING PLANTS	1	2	1	2
BATTERY CHANGERS	1	5	1	5
METERS	1	1	1	1
CONVERTERS	2	12	2	12
TRANSFORMERS	0	0	0	0
CIRCUIT BREAKERS	8	19	8	19
CONTROLLERS	49	195	56	226
GENERATORS	3	14	6	24
MOTORS	49	62	49	62
MOTOR GENERATORS	0	1	0	1
RELAYS	3	4	3	4
RHEOSTATS	0	0	0	0
SWITCHES	25	25	29	29
SWITCHBOARDS	4	14	4	14
VISUAL ALARMS	1	1	1	1
LIGHTING FIXTURES	2	2	2	2
GYRO COMPASSES	1	10	1	10
PROJECTION EQUIP	0	2	0	2
I/C EQUIP	2	9	2	9
NAVIGATIONAL EQUIP	2	24	3	29
INJECTORS	0	1	0	1
BURNERS	0	2	0	2
MARINE HARDWARE	2	4	2	4
REFRIG EQUIP	24	60	27	68
AIR CONDITIONING	1	4	1	4
STARTERS	1	5	1	5
WIPERS	0	1	0	1
AUDIBLE ALARMS	1	1	1	1
BEARINGS	1	1	1	1
INDICATORS	8	20	8	20
CLUTCHES	0	2	0	2
FANS	5	2	5	2
SHOP EQUIP	10	20	15	30
REGULATORS	1	5	1	5
GALLEY EQUIP	10	33	10	33
OEHYDRATORS	1	4	1	4
GAGES	7	8	7	8
TESTING EQUIP	3	14	3	14
FILTERS	10	25	10	25
PANELS	11	34	11	34

Patential Ouplicate APL's and Parts

Namenclature	1988 Patential APL Reductian	1988 Patential Parts Reductian	1989 Patential APL Reductian	1989 Patential Parts Reductian
ISOLATORS	Ø	Ø	Ø	Ø
HYORALIC EQUIP	11	64	13	77
CAPSTANS	Ø	1	Ø	2
REELS	2	6	2	7
OAVITS	Ø	Ø	Ø	Ø
CRANES	1	5	1	5
HOISTS	2	8	2	8
ELEVATORS	1	4	1	4
STEERING EQUIP	Ø	4	Ø	4
CONTROL EQUIP	17	56	17	56
WINCHES	3	21	4	25
WINOLASSES	Ø	2	Ø	2
FIREFIGHTING EQUIP	3	14	3	14
LUBRICATORS	1	2	1	2
ENGINES	2	231	2	231
PLUMBING EQUIP	1	1	1	1
GEARS AND REOUCERS	3	18	3	18
GOVERNORS	3	51	3	6Ø
IGNITION EQUIP	Ø	Ø	Ø	Ø
EJECTORS	Ø	1	Ø	1
EOUCTORS	Ø	Ø	Ø	Ø
STRAINERS	5	4	5	4
PURIFIERS	1	31	1	31
TRAPS-STEAM	1	1	1	1
COUPLINGS	4	4	5	5
SILENCING EQUIP	Ø	Ø	Ø	Ø
BRAKES	2	3	2	3
BLOWERS	Ø	6	Ø	6
WELOING SYSTEMS	2	9	2	9
BOAT PROPULSION	1	2	1	2
DECK MACHINERY	2	7	2	7
PHOTOGRAPHIC EQUIP	Ø	Ø	Ø	Ø
UNDERWATER LOG EQUIP	Ø	1	Ø	1
VALVES	99	149	99	149
MISC PARTS	11	183	11	183
LAUNORY EQUIP	14	97	17	116
TANKS	1	1	1	1
PIPE, HOSE, & FITTINGS	Ø	Ø	Ø	Ø
ASW EQUIP	1	7	1	7
YELLOW GEAR	61	152	61	152
PERISCOPES	Ø	2	Ø	2
MISC EQUIP	3	5	3	5
GRANO TOTALS	552	2,Ø17	582	2,132

APPENDIX D : NSLC MODEL

PTD. The cost of PTD, the first element of the model, "...refers only to the PTD development costs experienced by the contractor. Since these costs would be listed as 'Not Separately Priced' on the contract's supply schedule, they should be set equal to zero for the purposes of the government's life cycle cost formula."[115] Should the contractor bid based on government owned drawings, then by default the cost would be zero.

Provisioning. Costs for provisioning include "...PTD analysis, maintenance philosophies, and management data that go into establishing an APL."[116] Using the NAVSEA developed Level of Repair Analysis (LORA) model the formula is:

$$CP = 450 + 300(NPN) + 75(NP),$$

where CP is the Cost for provisioning;
NPN is the number of new parts being added to the supply system, and;
NP is the number of parts currently in the system.

Using the 25% factor for new parts discussed in Chapter III, the formula reduces to:

$$CP = 450 + 131.25(P),$$

where P is the number of different parts in the equipment.

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[115] LCDR Poe, Paper, p 7.

[116] LCDR Poe, Paper, p 7-8.

NSN. Increasing the NSN population results in additional management costs. A 1981 Army study found that it annually cost $448 to manage each NSN. This cost was comprised of:

"Supply Operations	$ 34.10
Requirements Computations	119.35
Logistics Data Management	85.25
Distribution and Transportation	102.30
DLSC Data Storage and Data Management	107.00"[117]

Using these costs, the formula for the additional management costs, CM, is:

$$CM = 448(NPN)(L),$$

where L is the projected life cycle of the equipment.

Training. The costs of training resulting from the introduction of a new piece of equipment include:

(a) Length of training
(b) Training equipment
(c) Course material
(d) Training site and maintenance costs
(e) Travel and labor costs

The length of training is dependent on the equipment's complexity. If the equipment is being introduced as a replacement, then it is assumed that the costs for (a) have been established and the value is zero.

The formula assumes that the current practice of using a training facility on both coasts will continue. Furthermore, the model assumes the costs to maintain each site will average 50% of the original procurement cost of the equipment per year per site, and that training will stop four years prior to the end of the projected life.

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[117] U.S. Army DARCOM Catalog Data Activity Memorandum, Cost to Establish and Maintain an NSN, 19 November 1981.

The formula for the total additional training costs is therefore:

$$CT = 2(PR) + .5(2PR)(L-4),$$

where CT is the cost of additional training
PR is the equipment unit price

The formula can be simplified to:

$$CT = PR(L-2).$$

Technical Manuals. The introduction of a new equipment or part requires changes to technical manuals. Using the LORA model as a basis, the cost for a manual is:

$$CTM = 62.5(P) + 20(Pop),$$

where CTM is the cost for technical manuals, and
Pop is the number of ships.

If the equipment is being introduced as a replacement, then it is assumed that the distribution costs have been established and the value is zero. The formula then becomes:

$$CTM = 62.5(P).$$

Installation Drawings. The addition of a new piece of equipment requires the one-time charge for installation drawings. Assuming that there is only one drawing needed for each ship class, then the formula is:

$$CD = 1{,}000(CL),$$

where CD is the cost for installation drawings, and
CL is the number of classes.

Configuration Control. The Consolidated Shipboard Allowance List (COSAL) is the single most important document used by the afloat supply officer to provide supply support while deployed. Maintenance of the COSAL through the OPNAV 4790/CK form by the NAVSEA system

prevents support degradation. This cost for processing the forms, as estimated by Ships Engineering Configuration Accounting System (SECAS) personnel, is $20 each. The formula is:

$$CC = 20(Pop),$$

where CC is the cost of configuration control.

This cost only covers computer related processing. It does not include the cost for the sailor to complete the form or for the system to make changes reflecting the new configuration.

Testing. A basic premise of the model is that the procurement is based on a performance specification. When an item is purchased on this basis, then first article testing is already included as one of the acquisition costs. If the equipment has been previously tested, then it is the government's prerogative whether to pay for further testing. In light of this argument, no testing costs are required.

Planned Maintenance. "Although Planned Maintenance (PMS) is an integral part of ILS, consideration in the economic analysis related to competitive procurement is minimal. The logic for this hypothesis is that if PMS is necessary to support the originally installed equipment, then the similarity between the competed equipment and the original equipment would necessitate similar PMS. The only significant difference would be in the identification of required repair parts on the individual Maintenance Requirement Cards (MRC), a review of the original Mrc's to assure compatibility with the competed equipment and promulgation of the new

MRC's. The average value for this non-recurring effort is estimated at $500.00."[118]

Total Costs. The formula for computing the total hidden ILS costs, C, that result from the introduction of new equipment is therefore:

$$C = 450 + 131.25(P) + 448(NPN)(L) + PR(L-2) + 62.5(P) + 1000(CL) + 20(Pop) + 500$$

[118] Mr. Richard Jones, H,M&E Standardization.

APPENDIX E : DESC MODEL[119]

Non-Standard Documentation. A National Aerospace Standards Committee (NASC) survey noted that it took an engineer between 2 and 145 hours to develop a drawing for a new part and that 67% of all drawings were for new parts. He then estimated that drawings per part for a stud averaged 27 manhours. (Other averages are provided, but this was the only pertinent H,M&E example.) Using a 1973 industry average of $25 per manhour and a conservative 50% rather than 67% for new part drawings, the cost formula for nonstandard documentation is:

$$DOC = (MH)(\$/MH)(\%ND),$$

where MH is the number of manhours,
$/MH is the cost per MH, and
%ND is the percentage of new drawings.

Substitution of the average costs above in this formula results in a drawing avoidance benefit of $337.50.

Testing. The formula for testing is:

$$TEST = (\%PT)(\$/T),$$

where TEST is the total cost for testing,
%PT is the percentage of parts tested, and
$/T is the average cost per test.

An NASC study indicated that 70% of all electronic parts are tested and MPCAG estimated that average cost for testing a mechanical part was

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[119] Messrs. Charles E. Gastineau and Donald L. Kerr, "Don't Cry: Justify", from The Economics of Standardization, edited by Robert B. Toth, p 63. Unless otherwise noted, information for this discussion is taken from Messrs. Gastineau's and Kerr's article.

$4,800. Again being conservative and using 25% (as opposed to 70%), the average cost to test is $1,200 per part.

NSN Management. The formula for NSN management, which includes both one-time charges and annual inventory maintenance costs, is:

$$IM = [(\$/C) + (y)(M\$/y)](\%ND)(NPN),$$

where IM is the total inventory management costs over y years,
$/C is the cost to catalog (a one-time charge),
y is the number of years (10 years in the model),
M$/y is the management cost per year, and
NPN is the number of new parts per drawing.

The NASC survey found that the average drawing contained 7.3 parts, but that only 3 were provisioned. (The article did not indicate whether the remaining 4.3 parts were already in the system or if the government intentionally decided against stocking them.) The survey also noted that a part had a life expectancy of 10 years before it was upgraded. Mr. Gastineau estimated that it cost $207 to enter a part into the system and a 1968 DLA report stated that it cost $165 per year to manage it. Assuming that the use of a standard prevented preparation of a drawing 50% of the time and thus excluded 3 new parts 50% of the time, inventory management costs are $2,785.50 per part.

Maintenance. The annual formula for depot maintenance is:

$$MC = (y)(\$R/y),$$

where MC is maintenance costs, and
$R/y is the annual repair costs.

The model uses a standard $300 per year for maintenance costs for Electronics, but $0 for H,M&E since it is not returned to a depot for repair. (This may not be a realistic assumption).

Total Costs. Combining the above elements results in the following per part total life cycle cost avoidance formula per part:

$$CA = (MH)(\$/MH)(\%ND) + (\%PT)(\$/T) + [(\$/C) + (y)(M\$/y)](\%ND)(NPN) + (y)(\$R/y).$$

Its value for the example is:

$$CA = \$4,323.00.$$

APPENDIX F : AIAA MODEL[120]

Increased Quantity Purchases. The savings attainable through increased quantity purchases is:

$$Sqb = Qn(Cn) - Qn(Cs),$$

where Sqb is the cost reduction resulting from volume purchases,
Qn is the number of parts purchased yearly if not replaced by a standard part,
Cn is the actual cost of the part, and
Cs is the price of the standard part based on the volume change.

Reduced Paperwork and Handling. The formula for savings attained through the reduction of paperwork is:

$$Spw = (N_1 - N_2)(K) + (D_1 - D_2)(J + M),$$

where Spw is the cost avoided through paperwork reduction,
N_1 is the number of orders before standardization,
N_2 is the number of orders after standardization,
K is the cost to process each order,
D_1 is the number of shipments received before standardization,
D_2 is the number of shipments received after standardization,
J is the cost of paperwork for storage processing, and
M is the receiving cost inspection.

Reduced Storage Requirements. The formula for savings achieved through reduced storage requirements is:

$$Ssp = (Ccf)(V_1 - V_2),$$

where Ssp is the savings accrued from reduced warehousing requirements,
Ccf is the annual cost to maintain one cubic foot of warehouse,
V_1 is the number of feet occupied before standardization, and
V_2 is the number of feet occupied after standardization.

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[120] This entire section is taken from the National Aerospace Standard 1524 of the Aerospace Industries of America, Chapter 5 of The Economics of Standardization, pp 94-106.

Reduced Engineering Search Time. The savings realized through the use of standard manuals is computed as:

$$Sys = (N)(Re)[(Tef)(Rs) - (Tsm)] - Cos,$$

where Sys is the savings avoided resulting from reduced search time,
N is the average number of searches,
Re is the burdened engineering rate per hour,
Tef is the time to perform each search using engineering files,
Rs is the search success rate using standard documents,
Tsm is the time to search in standard documents, and
Cos is the annual cost to publish and maintain standard documents.

Standard Stock vice Establishing a New Standard. The savings realized by using a standard part rather than preparing a new standard is computed as:

$$S_1 = (Q)(C_1 - C_2) + Ces + (I)[(Q/2)(C_1 - C_2)] + Y,$$

$$Sd = (Q)(C_1 - C_2) + (I)[(Q/2)(C_1 - C_2)] + Y,$$

where S_1 is the savings the first year,
Sd is the savings during succeeding years,
Q is the annual quantity purchased
C_1 is the unit cost of the new standard part,
C_2 is the unit cost of the new part if increased quantities are purchased,
Ces is the cost of establishing a new standard part,
I is the carrying cost, and
Y any additional savings, including intangibles that might be achieved.

Standard Stock vice New Design. The engineering savings realized by using a standard part rather than a new part is computed as:

$$S_1 = (Q)(C_1 - C_2) + Crs + Cqt + (I)[(Q/2)(C_1 - C_2)] + (He)(Re) + (Hd)(Rd) + Y,$$

$$Sd = (Q)(C_1 - C_2) + (I)[(Q/2)(C_1 - C_2)] + Y,$$

where Crs is the cost of issuing a part,
Cqt is the cost of qualification testing,
He is the estimated number of hours to engineer the new part,
Re is the standard, including overhead, engineering rate,
Hd is the estimated number of hours to design the part, and
Rd is the standard, including overhead, design hours.

Reduction of Inventory Range. The formula for computing savings resulting from inventory consolidation (Sri) is:

$$Sri = [Cmi - Cimp](N),$$

where Cmi is the annual cost for stocking and issuing a part,
Cimp is the cost to implement a standardization program on a per item basis, and
N is the number of parts eliminated.

Stocked Standard Part vice Nonstocked Part. The savings achieved by using stocked standard parts in lieu of nonstocked, nonstandard parts (Snp) is computed as:

$$Snp = (Ces - Cimp)(N).$$

Design Standards. The formula for computing savings achievable by using a design standard in lieu of detailing (Sds) the complete design is:

$$Sds = (Rd)[(N)(Hd_1 - Hd_2) - (Hes)] + Y,$$

where Hd_1 is the number of hours to detail the design element on an engineering drawing,
Hd_2 is the number of hours to specify a design standard on an engineering drawing, and
Hes is the additional savings that might be applicable.

APPENDIX G : NSLC AND DESC MODEL RESULTS

Appendix G provides the comparative results of the NSLC and DESC cost models discussed in Chapter IV, and described in Appendices D and E, and is presented in two parts. The first presents the NSLC model costs for 1987 through 1989 and the DESC model costs for 1987 and 1988. The second part presents the DESC model costs for 1989.

Stondordizotion Costs Using NSLC ond DESC Models

Nomencloture	1987 Cost NSLC Model	1988 Cost NSLC Model	1989 Cost NSLC Model	1987 Cost DESC Model	1988 Cost DESC Model
PUMPS	14,229,189	14,940,648	15,687,680	11,154,274	11,711,988
BOILERS	1,482,314	1,556,430	1,634,251	1,030,089	1,081,593
HEAT EXCHANGERS	860,866	903,910	949,105	624,628	655,860
CONDENSERS	256,973	269,822	283,313	135,610	142,391
TURBINES	4,937,001	5,183,851	5,443,043	2,940,959	3,088,007
COMPRESSORS	8,068,940	8,472,387	8,896,006	6,222,997	6,534,147
HEATERS	1,505,938	1,581,235	1,660,297	1,178,027	1,236,929
DISTILLING PLANTS	458,133	481,039	505,091	241,085	253,139
BATTERY CHANGERS	686,115	720,420	756,441	513,675	539,358
METERS	137,791	144,680	151,914	86,297	90,612
CONVERTERS	1,680,253	1,764,265	1,852,479	1,260,215	1,323,226
TRANSFORMERS	21,892	22,987	24,136	12,328	12,945
CIRCUIT BREAKERS	2,609,793	2,740,282	2,877,297	2,054,699	2,157,434
CONTROLLERS	24,509,528	28,240,289	34,306,350	19,329,023	22,271,812
GENERATORS	2,934,962	2,803,156	4,524,331	1,735,775	1,602,921
MOTORS	8,552,973	8,980,621	9,429,652	6,718,865	7,054,808
MOTOR GENERATORS	436,684	458,519	481,445	147,938	155,335
RELAYS	508,122	533,528	560,205	397,242	417,104
RHEOSTATS	60,973	64,021	67,223	41,094	43,149
SWITCHES	3,168,458	3,618,596	4,341,442	2,494,438	2,849,284
SWITCHBOARDS	1,974,051	2,072,753	2,176,391	1,499,930	1,574,927
VISUAL ALARMS	194,779	204,518	214,744	147,938	155,335
LIGHTING FIXTURES	333,528	350,205	367,715	260,262	273,275
GYRO COMPASSES	1,379,177	1,448,135	1,520,542	1,041,047	1,093,100
PROJECTION EQUIP	269,899	283,394	297,564	210,949	221,497
I/C EQUIP	1,304,110	1,369,316	1,437,782	1,008,172	1,058,581
NAVIGATIONAL EQUIP	2,963,583	3,500,108	4,396,540	2,332,673	2,755,660
INJECTORS	153,024	160,675	168,709	106,844	112,187
BURNERS	454,703	477,438	501,310	246,564	258,892
MARINE HARDWARE	571,514	600,090	630,094	438,336	460,252
REFRIG EQUIP	7,711,311	8,775,703	10,475,537	6,008,158	6,844,070
AIR CONDITIONING	622,869	654,012	686,713	462,092	486,142
STARTERS	808,546	848,974	891,422	575,316	604,081
WIPERS	148,944	156,391	164,210	115,063	120,816
AUDIBLE ALARMS	233,087	244,741	256,978	136,980	143,829
BEARINGS	266,070	279,374	293,342	95,886	100,680
INDICATORS	2,810,931	2,951,477	3,099,051	2,205,377	2,315,645
CLUTCHES	553,743	581,430	610,501	208,209	218,620
FANS	345,222	362,483	380,608	252,043	264,645
SHOP EQUIP	3,020,896	2,850,673	4,567,481	2,371,572	2,236,712
REGULATORS	732,734	769,370	807,839	567,097	595,452
GALLEY EQUIP	4,647,514	4,879,890	5,123,884	3,614,900	3,795,645
DEHYDRATORS	659,115	692,070	726,674	391,763	411,351
GAGES	1,143,830	1,201,021	1,261,072	890,369	934,688
TESTING EQUIP	1,913,703	2,009,388	2,109,858	1,490,341	1,564,858
FILTERS	3,459,091	3,632,046	3,813,648	2,712,202	2,847,812
PANELS	4,688,519	4,922,945	5,169,092	3,682,020	3,866,121

Standardization Costs Using NSLC and DESC Models

Nomenclature	1987 Cost NSLC Model	1988 Cost NSLC Model	1989 Cost NSLC Model	1987 Cost DESC Model	1988 Cost DESC Model
ISOLATORS	49,517	51,993	54,593	Ø	Ø
HYDRALIC EQUIP	8,182,617	9,637,Ø12	12,Ø6Ø,641	6,2Ø9,729	7,344,79Ø
CAPSTANS	418,422	429,82Ø	525,435	119,187	117,634
REELS	752,929	865,872	1,Ø49,Ø44	574,583	662,711
DAVITS	187,88Ø	197,274	2Ø7,138	38,354	4Ø,272
CRANES	1,482,815	1,556,956	1,634,8Ø4	542,44Ø	569,562
HOISTS	1,182,644	1,241,776	1,3Ø3,864	91Ø,916	956,462
ELEVATORS	6Ø5,611	635,891	667,686	427,377	448,746
STEERING EQUIP	497,369	522,238	548,349	39Ø.393	4Ø9,912
CONTROL EQUIP	7,664,3Ø9	8,Ø47,524	8,449,9ØØ	6,Ø36,7Ø5	6,338,54Ø
WINCHES	2,894,692	3,346,629	4,Ø84,647	2,Ø67,313	2,413,Ø2Ø
WINDLASSES	445,856	468,149	491,556	191,772	2Ø1,36Ø
FIREFIGHTING EQUIP	2,ØØ7,877	2,1Ø8,27Ø	2,213,684	1,561,571	1,639,65Ø
LUBRICATORS	256,383	269,2Ø2	282,662	191,772	2Ø1.36Ø
ENGINES	32,411,991	34,Ø32,591	35,734,221	25,Ø83,761	26,337,949
PLUMBING EQUIP	158,769	166,7Ø7	175,Ø43	123,282	129,446
GEARS AND REDUCERS	2,887,Ø31	3,Ø31,382	3,182,952	1,986,2Ø9	2,Ø85,519
GOVERNORS	6,379,558	7,473,522	9,286,882	4,95Ø,ØØ2	5,8Ø8,863
IGNITION EQUIP	3Ø,497	32,Ø22	33,623	Ø	Ø
EJECTORS	226,589	237,918	249,814	1Ø2,735	1Ø7,872
EDUCTORS	49,398	55,Ø41	63,69Ø	16,414	19,738
STRAINERS	56Ø,774	588,813	618,254	439,7Ø6	461,691
PURIFIERS	4,422,Ø73	4,643,176	4,875,335	3,347,789	3,515,178
TRAPS-STEAM	1Ø2,784	1Ø7,923	113,32Ø	76,7Ø9	8Ø,544
COUPLINGS	686,391	783,655	939,77Ø	427,7Ø9	498,749
SILENCING EQUIP	45,588	47,868	5Ø,261	28,766	3Ø,2Ø4
BRAKES	446,462	468,785	492,224	336,971	353,819
BLOWERS	846,635	888,967	933,415	6Ø4,Ø81	634,285
WELDING SYSTEMS	1,256,181	1,318,99Ø	1,384,939	988,995	1,Ø38,445
BOAT PROPULSION	712,382	748,ØØ1	785,4Ø1	249,3Ø3	261,769
DECK MACHINERY	953,546	1,ØØ1,223	1,Ø51,284	723,254	759,417
PHOTOGRAPHIC EQUIP	65,ØØ3	68,253	71,365	49,313	51,778
UNDERWATER LOG EQUIP	166,664	174,997	183,747	82,188	86,297
VALVES	2Ø,5Ø7,789	21,533,178	22,6Ø9,837	16,174,588	16,983,317
MISC PARTS	25,238,899	26,5ØØ,844	27,825,886	19,9ØØ,441	2Ø,895,463
LAUNDRY EQUIP	11,877,3ØØ	14,Ø34,Ø1Ø	17,638,994	9,325,41Ø	11,Ø24,558
TANKS	567,142	595,499	625,274	157,527	165,4Ø3
PIPE, HOSE, & FITTINGS	87,432	91,8Ø4	96,394	21,917	23,Ø13
ASW EQUIP	1,ØØ9,813	1,Ø6Ø,3Ø4	1,113,319	712.296	747,91Ø
YELLOW GEAR	2Ø,96Ø,978	22,ØØ9,Ø27	23,1Ø9,478	16,533,475	17,36Ø,149
PERISCOPES	421,779	442,868	465,Ø12	271,22Ø	284,781
MISC EQUIP	649,112	681,568	715,646	5Ø8,195	533,6Ø5
GRAND TOTALS	28Ø,828,871	3Ø1,956,85Ø	334,58Ø,69Ø	213,876,627	23Ø,16Ø,797

Namenclature	1989 Cost DESC Model
PUMPS	12,297,587
BOILERS	1,135,673
HEAT EXCHANGERS	688,653
CONDENSERS	149,510
TURBINES	3,242,407
COMPRESSORS	6,860,855
HEATERS	1,298,775
DISTILLING PLANTS	265,796
BATTERY CHANGERS	566,326
METERS	95,143
CONVERTERS	1,389,387
TRANSFORMERS	13,592
CIRCUIT BREAKERS	2,265,305
CONTROLLERS	27,056,830
GENERATORS	2,930,176
MOTORS	7,407,548
MOTOR GENERATORS	163,102
RELAYS	437,959
RHEOSTATS	45,306
SWITCHES	3,419,249
SWITCHBOARDS	1,653,673
VISUAL ALARMS	163,102
LIGHTING FIXTURES	286,939
GYRO COMPASSES	1,147,755
PROJECTION EQUIP	232,571
I/C EQUIP	1,111,510
NAVIGATIONAL EQUIP	3,462,553
INJECTORS	117,796
BURNERS	271,837
MARINE HARDWARE	483,265
REFRIG EQUIP	8,181,074
AIR CONDITIONING	510,449
STARTERS	634,285
WIPERS	126,857
AUDIBLE ALARMS	151,020
BEARINGS	105,714
INDICATORS	2,431,428
CLUTCHES	229,551
FANS	277,877
SHOP EQUIP	3,590,442
REGULATORS	625,224
GALLEY EQUIP	3,985,427
DEHYDRATORS	431,918
GAGES	981,632
TESTING EQUIP	1,643,101
FILTERS	2,990,203
PANELS	4,059,427

Nomenclature	1989 Cost DESC Model
ISOLATORS	Ø
HYDRALIC EQUIP	9,243,836
CAPSTANS	181,99Ø
REELS	8Ø6,192
DAVITS	42,286
CRANES	598,Ø41
HOISTS	1,ØØ4,285
ELEVATORS	471,183
STEERING EQUIP	43Ø,4Ø8
CONTROL EQUIP	6,655,467
WINCHES	2,983,868
WINDLASSES	211,428
FIREFIGHTING EQUIP	1,721,632
LUBRICATORS	211,428
ENGINES	27,654,847
PLUMBING EQUIP	135,918
GEARS AND REDUCERS	2,189,795
GOVERNORS	7,235,Ø27
IGNITION EQUIP	Ø
EJECTORS	113,265
EDUCTORS	25,376
STRAINERS	484,775
PURIFIERS	3,69Ø,937
TRAPS-STEAM	84,571
COUPLINGS	515,931
SILENCING EQUIP	31,714
BRAKES	371,51Ø
BLOWERS	666,ØØØ
WELDING SYSTEMS	1,Ø9Ø,367
BOAT PROPULSION	274,857
DECK MACHINERY	797,387
PHOTOGRAPHIC EQUIP	54,367
UNDERWATER LOG EQUIP	9Ø,612
VALVES	17,832,483
MISC PARTS	21,94Ø,237
LAUNDRY EQUIP	13,866,Ø94
TANKS	173,673
PIPE, HOSE, & FITTINGS	24,163
ASW EQUIP	785,3Ø6
YELLOW GEAR	18,228,156
PERISCOPES	299,Ø2Ø
MISC EQUIP	56Ø,286
GRAND TOTALS	255,494,533

APPENDIX H : STANDARDIZATION COSTING MODEL[121]

As noted in Chapter IV, the model combines the elements from both the NSLC and DESC models. In many cases, the formulas are repeated so the reader does not have to keep referring to previous appendices. Justification for element selection will only be provided where the formulas deviate from their predecessors.

1. NON-RECURRING COSTS

Non-Standard Technical Data. Technical data must be purchased when a new equipment is introduced if the supply system is to ensure proper support. As discussed in Chapter IV, the NSLC Data Ownership Model for estimating technical data required too many broad assumptions to be valid. Using a Best Replacement Factor (BRF) of 10%, a system life of 10 years, and not compensating for testing costs, the NSLC model estimated a technical data cost of $9.549M per new pump per year. This value was intuitively too high to be acceptable. However, the costs are required if the model is to be valid. The next alternative was the non-standard documentation costs provided in the DESC model.

The AIAA survey found that each drawing contained an average of 7.3 parts, and that 67% of the parts were new to the supply system. This equated to 4.89 parts per drawing. For conservative purposes, a median

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[121] All constants used in the actual calculation were inflated at an annual rate of 5%. However, in this appendix the values used in the NSLC and DESC models are presented to prevent confusion in understanding the derivation of the model.

of 4 nonstandard parts/drawing was used in the model. Additionally, the number of drawings needed were rounded to the nearest complete drawing. Thus the cost formula for drawings is:

$$DOC = (MH)(\$/MH)[(NSP)/4](E),$$

where NSP is the number of Non-Standard Parts, and
E is the number of new equipment.

In 1982 DESC updated the cost per MH ($/MH) to $52/hour. Otherwise the 27 hours per drawing (M/H) remains consistent with the previous explanation. This formula was obtained from the DESC Model.

Provisioning. For ease in writing the equation in the software, this formula was left in its original state.

$$CP = 450 + \{[300(NSP) + 75(SP)](E)\},$$

where SP is the number of Standardized Parts per each new equipment. This formula was obtained from the NSLC Model.

Testing. With the increasing attention to quality control, the percentage tested (%PT) was increased from DESC's estimate of 25 to 50%. Additionally, in 1982 DESC increased the cost per test to $7,872 ($/T).

$$TEST = (\%PT)(\$/T)(NSP)(E).$$

Technical Manuals. The NSLC model assumes that the technical manual distribution costs have already been established. However, when an equipment is introduced, the manuals must still be sent to the fleet, so the cost for distribution is included in the algorithm. The formula for the cost of technical manuals (CTM) is:

$$CTM = 62.5(P) + 20(Pop),$$

where P is the number parts in the equipment, and
Pop is the number of ships where the equipment is installed.

This formula was obtained from the NSLC Model.

Installation Drawings

$$CD = 1{,}000(CL).$$

CD is the cost of drawings, and
CL is the number of classes of ships where the equipment is installed.

This formula was obtained from the NSLC Model.

Training Equipment. There are two costs for training, one for establishing the program and the other for annual operating expenses. This element considers the non-recurring costs for starting the program.

$$CT = 2(PR).$$

CT is the cost of training equipment, and
PR is the equipment unit price.

Planned Maintenance

$$CPM = \$500.$$

CPM is the cost for planned maintenance.

This formula was obtained from the NSLC Model.

2. ANNUAL OPERATING COSTS

The operating costs are based on a 10-year life-cycle. The present value is computed using a 10% discount factor. Initially, the model was run using a 5% inflation factor for year 1. It was not factored in the annual costs for years 2 through 10. A second calculation was run computing the Net Present Value (NPV) assuming a 5% annual inflation rate.

NSN Management Costs

$$CM = 448(NSP)(E).$$

This formula was obtained from the NSLC Model.

Training. Unlike the NSLC model, it is assumed that training on the equipment continues until the equipment is replaced.

$$CT = PR.$$

This formula was derived from the NSLC Model.

Configuration Control. Configuration control is an ongoing effort. It does not stop once the equipment is deployed. However, only parts that fail more than anticipated receive any attention.[122] The NSLC model is modified to reflect the failure rates of the parts. An arbitrary value of 10% was selected for the BRF. But the NSLC model only considers the cost to process OPNAV 4790/CK Forms. It does not include the time for a sailor to complete the form, an engineer to revise the part, and the configuration control board to meet and approve the change. Therefore, the $20 per effort remains to compensate for the shortcomings, despite the change in the formula logic.

$$CC = 20(BRF)(NSP)(E).$$

This formula was obtained from the NSLC Model.

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[122] This assumes that the equipment is not constantly upgraded, and therefore the parts baseline remains stable.

Summarizing the formulas, the model for non-recurring costs is:

$$\{(MH)(\$/MH)[(NSP)/4](E)\} +$$
$$\{450 + \{[300(NSP) + 75(SP)](E)\}\} + \{(\%PT)(\$/T)(NSP)(E)\} +$$
$$\{62.5P + 20(Pop)\} + \{1{,}000(CL)\} + \{2PR\} + \{500\},$$

and the model for annual costs is:

$$\{448(NSP)(E)\} + \{PR\} + \{20(BRF)(NSP)(E)\}.$$

APPENDIX I : STANDARDIZATION COSTING MODEL RESULTS

Appendix I provides the results of the Standardization Costing Model, I.1, and Duplication Reduction Savings, I.2, discussed in Chapter IV and described in Appendix H. In I.1 costs for each year are segregated in three columns. The first column for each year is the sum of the non-recurring costs and the present value, for ten years at 10%, of the annual costs for non-standardization. The second column lists the values of the non-recurring costs included in the first column. These are the "one-time" charges incurred when a new piece of equipment is introduced to the fleet. The third column provides the annual costs resulting from non-standardization. Only the annual cost for a single year is shown.

I.2 provides the results of the Standardization Costing Model when applied to reduction of duplicate parts.

I.1 1987 - 1989 Summory Estimoted Costs for Non-Standardizotion (Uninflated)

Nomencloture	Totol 1987 Est Costs	1987 Non-Recurring Costs	1987 Annuol Costs	Totol 1988 Est Costs	1988 Non-Recurring Costs
PUMPS	20,633,902	13,026,775	1,238,025	21,665,597	13,678,113
BOILERS	2,083,530	1,253,520	135,080	2,187,707	1,316,196
HEAT EXCHANGERS	1,302,938	829,562	77,040	1,374,883	877,838
CONDENSERS	351,036	195,939	25,241	369,899	207,048
TURBINES	6,659,083	3,744,384	474,354	6,992,037	3,931,604
COMPRESSORS	11,694,234	7,350,858	706,864	12,278,946	7,718,401
HEATERS	2,485,102	1,680,980	130,867	2,629,872	1,785,543
DISTILLING PLANTS	600,398	322,191	45,277	630,418	338,301
BATTERY CHANGERS	999,228	627,048	60,570	1,052,171	661,383
METERS	229,186	150,953	12,732	243,150	161,005
CONVERTERS	2,379,835	1,466,289	148,675	2,498,827	1,539,604
TRANSFORMERS	48,673	37,441	1,828	52,180	40,387
CIRCUIT BREAKERS	3,974,302	2,583,275	226,383	4,190,907	2,730,329
CONTROLLERS	35,698,449	22,628,444	2,127,083	41,132,682	26,073,183
GENERATORS	3,944,619	2,208,914	282,478	3,737,151	2,063,206
MOTORS	14,137,183	9,569,626	743,349	14,961,045	10,165,110
MOTOR GENERATORS	535,266	245,808	47,108	563,103	259,172
RELAYS	838,281	568,157	43,961	887,113	603,483
RHEOSTATS	95,239	62,553	5,320	100,716	66,396
SWITCHES	5,449,735	3,760,499	274,915	6,283,458	4,354,197
SWITCHBOARDS	2,887,896	1,820,042	173,788	3,040,998	1,919,751
VISUAL ALARMS	309,573	205,916	16,870	327,199	218,358
LIGHTING FIXTURES	549,835	373,040	28,772	581,859	396,225
GYRO COMPASSES	1,969,390	1,221,858	121,657	2,067,860	1,282,951
PROJECTION EQUIP	392,681	250,081	23,208	412,316	262,585
I/C EQUIP	1,888,130	1,188,469	113,867	1,982,536	1,247,892
NAVIGATIONAL EQUIP	4,326,667	2,746,641	257,142	5,110,352	3,244,232
INJECTORS	217,160	133,343	13,641	228,018	140,010
BURNERS	597,713	323,771	44,583	627,599	339,959
MARINE HARDWARE	881,137	574,555	49,895	929,965	608,054
REFRIG EQUIP	11,702,814	7,570,176	672,568	13,379,145	8,677,378
AIR CONDITIONING	913,093	574,405	55,120	961,849	606,227
STARTERS	1,146,098	698,229	72,889	1,203,402	733,140
WIPERS	219,875	141,637	12,733	231,584	149,435
AUDIBLE ALARMS	325,080	188,738	22,189	342,527	199,367
BEARINGS	348,321	174,414	28,303	367,407	184,805
INDICATORS	4,275,683	2,775,017	244,227	4,508,670	2,932,970
CLUTCHES	676,772	315,344	58,821	710,610	331,111
FANS	681,346	493,124	30,632	726,386	528,752
SHOP EQUIP	4,694,994	3,082,525	262,422	4,452,781	2,931,012
REGULATORS	1,056,058	663,973	63,810	1,108,861	697,171
GALLEY EQUIP	6,909,903	4,418,144	405,522	7,279,610	4,663,263
DEHYDRATORS	880,047	492,319	63,101	924,049	516,935
GAGES	1,883,986	1,272,369	99,538	1,993,690	1,351,493
TESTING EQUIP	2,776,803	1,752,445	166,709	2,915,643	1,840,068
FILTERS	5,260,514	3,412,867	300,696	5,547,155	3,607,125
PANELS	7,031,506	4,528,230	407,397	7,409,798	4,781,358

I.1 1987 - 1989 Summory Estimoted Costs for Non-Standordizotion (Uninfloted)

Nomenclature	Totol 1987 Est Costs	1987 Non-Recurring Costs	1987 Annuol Costs	Totol 1988 Est Costs	1988 Non-Recurring Costs
ISOLATORS	50,367	14,248	5,878	52,885	14,961
HYDRALIC EQUIP	11,628,248	7,193,610	721,717	13,711,721	8,497,943
CAPSTANS	495,723	211,734	46,218	507,065	213,955
REELS	1,112,751	707,382	65,972	1,285,069	819,278
DAVITS	218,566	87,591	21,316	229,971	92,447
CRANES	1,806,211	830,670	158,765	1,896,521	872,204
HOISTS	1,698,639	1,063,326	103,394	1,783,571	1,116,492
ELEVATORS	862,176	526,143	54,688	905,284	552,450
STEERING EQUIP	727,272	463,369	42,949	763,636	486,537
CONTROL EQUIP	11,440,667	7,352,628	665,310	12,053,133	7,760,691
WINCHES	4,135,294	2,529,199	261,385	4,794,115	2,943,894
WINDLASSES	559,141	275,685	46,131	587,098	289,469
FIREFIGHTING EQUIP	2,892,119	1,816,631	175,031	3,036,725	1,907,463
LUBRICATORS	383,928	246,001	22,447	404,794	259,971
ENGINES	46,924,275	29,497,472	2,836,132	49,270,489	30,972,346
PLUMBING EQUIP	242,924	159,586	13,563	256,262	168,758
GEARS AND REDUCERS	4,060,198	2,435,847	264,356	4,263,208	2,557,640
GOVERNORS	9,217,447	5,792,738	557,356	10,803,576	6,794,355
IGNITION EQUIP	31,003	9,493	3,501	32,553	9,968
EJECTORS	290,790	149,246	23,036	305,926	157,305
EDUCTORS	71,731	40,590	5,068	82,645	48,254
STRAINERS	1,024,089	726,163	48,486	1,088,055	775,233
PURIFIERS	6,368,981	3,970,873	390,281	6,687,430	4,169,417
TRAPS-STEAM	172,991	118,791	8,821	183,310	126,400
COUPLINGS	1,080,099	682,120	64,769	1,252,799	801,354
SILENCING EQUIP	76,017	51,478	3,994	80,653	54,887
BRAKES	708,046	467,342	39,173	748,338	495,599
BLOWERS	1,196,723	728,162	76,256	1,256,559	764,570
WELDING SYSTEMS	1,815,905	1,147,350	108,804	1,906,700	1,204,717
BOAT PROPULSION	902,893	431,851	76,660	951,139	456,544
DECK MACHINERY	1,423,476	908,271	83,847	1,500,375	959,409
PHOTOGRAPHIC EQUIP	96,377	63,042	5,425	101,554	66,552
UNDERWATER LOG EQUIP	215,772	114,138	16,540	226,560	119,845
VALVES	33,049,257	22,113,978	1,779,666	34,936,440	23,454,397
MISC PARTS	36,758,683	23,298,548	2,190,575	38,596,617	24,463,476
LAUNDRY EQUIP	17,385,312	11,040,254	1,032,629	20,545,488	13,049,759
TANKS	704,648	317,843	62,951	742,623	336,478
PIPE, HOSE, & FITTINGS	108,509	49,792	9,556	114,411	52,758
ASW EQUIP	1,419,541	857,856	91,412	1,490,518	900,748
YELLOW GEAR	31,940,338	20,763,798	1,818,930	33,681,312	21,945,945
PERISCOPES	579,470	338,154	39,273	608,444	355,062
MISC EQUIP	1,022,997	677,607	56,211	1,080,468	717,809
GRAND TOTALS	415,842,887	263,975,488	24,715,720	448,009,771	284,769,963

I.1 1987 - 1989 Summary Estimated Costs for Non-Standordization (Uninfloted)

Nomencloture	1988 Annuol Costs	Totol 1989 Est Costs	1989 Non-Recurring Costs	1989 Annual Costs
PUMPS	1,299,926	22,748,876	14,362,Ø19	1,364,922
BOILERS	141,834	2,297,Ø92	1,382,ØØ6	148,926
HEAT EXCHANGERS	8Ø,892	1,451,167	929,269	84,936
CONDENSERS	26,5Ø3	389,849	218,855	27,828
TURBINES	498,Ø72	7,341,639	4,128,184	522,975
COMPRESSORS	742,2Ø8	12,892,893	8,1Ø4,321	779,318
HEATERS	137,411	2,784,115	1,897,57Ø	144,281
DISTILLING PLANTS	47,541	661,939	355,216	49,918
BATTERY CHANGERS	63,599	1,1Ø8,Ø86	697,758	66,779
METERS	13,369	258,Ø85	171,833	14,Ø37
CONVERTERS	156,1Ø9	2,623,768	1,616,584	163,915
TRANSFORMERS	1,919	55,979	43,596	2,Ø15
CIRCUIT BREAKERS	237,7Ø2	4,42Ø,293	2,886,686	249,587
CONTROLLERS	2,45Ø,864	49,968,613	31,674,274	2,977,32Ø
GENERATORS	272,427	6,22Ø,993	3,62Ø,24Ø	423,261
MOTORS	78Ø,516	15,838,851	1Ø,8Ø3,12Ø	819,542
MOTOR GENERATORS	49,463	592,449	273,321	51,937
RELAYS	46,16Ø	939,14Ø	641,328	48,468
RHEOSTATS	5,586	1Ø6,546	7Ø,5Ø9	5,865
SWITCHES	313,978	7,614,233	5,299,521	376,7Ø9
SWITCHBOARDS	182,478	3,2Ø2,7Ø3	2,Ø25,394	191,6Ø2
VISUAL ALARMS	17,713	345,94Ø	231,657	18,599
LIGHTING FIXTURES	3Ø,211	615,978	421,Ø62	31,722
GYRO COMPASSES	127,74Ø	2,171,253	1,347,Ø99	134,127
PROJECTION EQUIP	24,368	432,931	275,714	25,586
I/C EQUIP	119,56Ø	2,Ø81,663	1,31Ø,287	125,538
NAVIGATIONAL EQUIP	3Ø3,7Ø3	6,419,835	4,Ø75,693	381,498
INJECTORS	14,323	239,419	147,Ø1Ø	15,Ø39
BURNERS	46,812	658,978	356,957	49,153
MARINE HARDWARE	52,39Ø	981,754	643,747	55,Ø09
REFRIG EQUIP	765,11Ø	16,Ø49,669	1Ø,44Ø,859	912,8Ø8
AIR CONDITIONING	57,876	1,Ø13,38Ø	639,977	6Ø,77Ø
STARTERS	76,533	1,263,572	769,797	8Ø,36Ø
WIPERS	13,369	243,957	157,7ØØ	14,Ø38
AUDIBLE ALARMS	23,299	36Ø,976	21Ø,658	24,463
BEARINGS	29,718	387,629	195,897	31,2Ø4
INDICATORS	256,438	4,755,398	3,1ØØ,913	269,26Ø
CLUTCHES	61,762	746,141	347,666	64,85Ø
FANS	32,164	774,874	567,359	33,772
SHOP EQUIP	247,661	7,178,417	4,741,Ø45	396,671
REGULATORS	67,ØØ1	1,164,3Ø4	732,Ø3Ø	7Ø,351
GALLEY EQUIP	425,798	7,67Ø,44Ø	4,923,276	447,Ø88
DEHYDRATORS	66,256	97Ø,252	542,782	69,569
GAGES	1Ø4,515	2,11Ø,57Ø	1,436,262	1Ø9,74Ø
TESTING EQUIP	175,Ø45	3,Ø61,425	1,932,Ø71	183,797
FILTERS	315,731	5,85Ø,7Ø1	3,813,67Ø	331,517
PANELS	427,766	7,8Ø9,915	5,Ø5Ø,Ø53	449,155

I.1 1987 - 1989 Summory Estimated Costs for Non-Stondordizotion (Uninflated)

Nomenclature	1988 Annuol Costs	Totol 1989 Est Costs	1989 Non-Recurring Costs	1989 Annual Costs
ISOLATORS	6,172	55,530	15,709	6,481
HYDRALIC EQUIP	848,518	17,187,673	10,677,714	1,059,466
CAPSTANS	47,702	643,505	296,212	56,520
REELS	75,805	1,564,362	1,000,688	91,735
DAVITS	22,381	241,999	97,599	23,501
CRANES	166,703	1,991,347	915,814	175,038
HOISTS	108,564	1,872,749	1,172,317	113,992
ELEVATORS	57,422	950,549	580,073	60,293
STEERING EQUIP	45,097	801,818	510,864	47,351
CONTROL EQUIP	698,575	12,700,628	8,193,564	733,504
WINCHES	301,115	5,873,603	3,626,540	365,699
WINDLASSES	48,438	616,453	303,943	50,860
FIREFIGHTING EQUIP	183,782	3,188,561	2,002,836	192,971
LUBRICATORS	23,569	426,885	274,821	24,748
ENGINES	2,977,939	51,734,013	32,520,963	3,126,835
PLUMBING EQUIP	14,241	270,398	178;518	14,953
GEARS AND REDUCERS	277,573	4,476,368	2,685,522	291,452
GOVERNORS	652,482	13,434,137	8,456,713	810,053
IGNITION EQUIP	3,676	34,181	10,466	3,859
EJECTORS	24,187	321,884	165,831	25,397
EDUCTORS	5,597	100,172	60,917	6,389
STRAINERS	50,910	1,156,610	828,147	53,456
PURIFIERS	409,795	7,021,801	4,377,887	430,285
TRAPS-STEAM	9,262	194,327	134,572	9,725
COUPLINGS	73,470	1,532,128	995,755	87,292
SILENCING EQUIP	4,193	85,612	58,557	4,403
BRAKES	41,132	791,178	525,802	43,189
BLOWERS	80,069	1,319,387	802,798	84,072
WELDING SYSTEMS	114,245	2,002,035	1,264,953	119,957
BOAT PROPULSION	80,493	1,002,134	482,810	84,518
DECK MACHINERY	88,040	1,581,743	1,013,728	92,442
PHOTOGRAPHIC EQUIP	5,696	107,029	70,277	5,981
UNDERWATER LOG EQUIP	17,367	237,888	125,837	18,236
VALVES	1,868,650	36,943,564	24,887,419	1,962,082
MISC PARTS	2,300,104	40,526,448	25,686,649	2,415,109
LAUNDRY EQUIP	1,219,895	25,828,569	16,409,818	1,532,858
TANKS	66,098	782,796	356,344	69,403
PIPE, HOSE, & FITTINGS	10,034	120,661	55,925	10,535
ASW EQUIP	95,982	1,565,044	945,786	100,781
YELLOW GEAR	1,909,877	35,525,024	23,202,889	2,005,371
PERISCOPES	41,237	638,866	372,815	43,299
MISC EQUIP	59,021	1,141,502	760,710	61,972
GRAND TOTALS	26,566,527	497,467,845	316,719,951	29,415,887

I.2 1987 - 1989 Duplication Reduction Savings (Uninflated)

Nomenclature	Duplicate Reduction Savings	1987 Annual Parts Reduction Savings	1988 Annual Parts Reduction Savings	1989 Annual Parts Reduction Savings
PUMPS	966,459	72,741	76,378	80,197
BOILERS	163,131	27,467	28,841	30,283
HEAT EXCHANGERS	110,107	11,785	12,374	12,993
CONDENSERS	64,808	11,074	11,628	12,209
TURBINES	927,605	167,113	175,468	184,242
COMPRESSORS	494,831	56,750	59,587	62,567
HEATERS	97,090	7,799	8,189	8,598
DISTILLING PLANTS	57,645	20,091	21,095	22,150
BATTERY CHANGERS	37,101	6,907	7,252	7,615
METERS	13,242	3,717	3,902	4,098
CONVERTERS	124,815	17,021	17,872	18,766
TRANSFORMERS	7,141	540	567	595
CIRCUIT BREAKERS	301,971	11,729	12,316	12,932
CONTROLLERS	1,436,175	107,786	124,135	150,700
GENERATORS	182,425	101,142	104,981	117,146
MOTORS	536,421	41,431	43,503	45,678
MOTOR GENERATORS	62,827	31,653	33,236	34,897
RELAYS	58,862	2,462	2,585	2,714
RHEOSTATS	20,130	1,026	1,078	1,132
SWITCHES	281,844	14,322	16,314	19,501
SWITCHBOARDS	332,247	17,091	17,946	18,843
VISUAL ALARMS	28,623	1,415	1,485	1,560
LIGHTING FIXTURES	39,449	1,583	1,662	1,745
GYRO COMPASSES	239,775	12,899	13,544	14,222
PROJECTION EQUIP	31,584	1,170	1,228	1,290
I/C EQUIP	159,247	8,543	8,970	9,419
NAVIGATIONAL EQUIP	110,578	13,448	15,820	19,766
INJECTORS	15,909	2,479	2,603	2,733
BURNERS	47,264	18,824	19,766	20,754
MARINE HARDWARE	97,259	4,102	4,307	4,522
REFRIG EQUIP	270,374	44,897	50,112	59,134
AIR CONDITIONING	24,526	6,751	7,089	7,443
STARTERS	58,817	12,786	13,425	14,096
WIPERS	19,003	712	748	785
AUDIBLE ALARMS	14,639	7,879	8,273	8,686
BEARINGS	41,757	18,285	19,200	20,160
INDICATORS	168,105	13,832	14,523	15,249
CLUTCHES	56,986	37,069	38,923	40,869
FANS	37,724	4,302	4,517	4,742
SHOP EQUIP	196,456	14,664	13,992	21,579
REGULATORS	122,288	4,566	4,794	5,034
GALLEY EQUIP	219,346	27,875	29,269	30,732
DEHYDRATORS	61,278	22,174	23,282	24,446
GAGES	125,094	6,521	6,847	7,190
TESTING EQUIP	80,167	11,014	11,565	12,143
FILTERS	272,957	17,353	18,221	19,132
PANELS	391,080	22,737	23,874	25,068

I.2 1987 - 1989 Duplicatian Reductian Savings (Uninflated)

Namenclature	Duplicate Reduction Savings	1987 Annual Parts Reductian Savings	1988 Annual Parts Reductian Savings	1989 Annual Parts Reductian Savings
ISOLATORS	6,942	5,878	6,172	6,481
HYDRALIC EQUIP	277,553	72,988	81,210	93,765
CAPSTANS	49,057	33,766	35,413	37,508
REELS	32,976	5,945	6,572	7,513
DAVITS	27,252	17,309	18,174	19,083
CRANES	183,039	102,096	107,201	112,561
HOISTS	106,659	8,231	8,643	9,075
ELEVATORS	153,816	10,040	10,542	11,069
STEERING EQUIP	57,152	2,165	2,273	2,387
CONTROL EQUIP	671,183	34,657	36,390	38,209
WINCHES	180,490	45,413	49,027	53,975
WINDLASSES	68,102	26,097	27,402	28,772
FIREFIGHTING EQUIP	53,026	11,894	12,489	13,113
LUBRICATORS	20,567	2,413	2,533	2,660
ENGINES	1,752,331	215,639	226,421	237,742
PLUMBING EQUIP	17,706	684	718	754
GEARS AND REDUCERS	343,004	56,857	59,700	62,685
GOVERNORS	217,188	40,230	45,632	54,212
IGNITION EQUIP	4,199	3,501	3,676	3,859
EJECTORS	59,018	12,303	12,918	13,564
EDUCTORS	8,868	3,353	3,335	3,738
STRAINERS	95,616	2,550	2,678	2,812
PURIFIERS	212,617	40,538	42,565	44,694
TRAPS-STEAM	31,191	807	847	890
COUPLINGS	46,336	20,087	21,366	22,946
SILENCING EQUIP	4,498	988	1,038	1,090
BRAKES	39,838	3,970	4,169	4,377
BLOWERS	99,127	13,148	13,805	14,496
WELDING SYSTEMS	52,967	5,484	5,758	6,046
BOAT PROPULSION	97,566	50,615	53,146	55,803
DECK MACHINERY	143,231	8,289	8,704	9,139
PHOTOGRAPHIC EQUIP	6,563	273	287	301
UNDERWATER LOG EQUIP	54,669	7,954	8,352	8,770
VALVES	2,700,763	89,912	94,407	99,128
MISC PARTS	1,166,994	111,582	117,161	123,019
LAUNDRY EQUIP	126,011	58,406	68,163	84,272
TANKS	74,637	46,494	48,819	51,260
PIPE, HOSE, & FITTINGS	11,368	7,266	7,630	8,011
ASW EQUIP	40,698	16,998	17,848	18,741
YELLOW GEAR	135,740	91,683	96,267	101,081
PERISCOPES	99,925	10,939	11,486	12,060
MISC EQUIP	91,012	3,120	3,276	3,439
GRAND TOTALS	18,828,660	2,372,092	2,521,696	2,724,449

APPENDIX J: INVENTORY DEPTH INCREASE

Appendix J provides the estimates for the number of parts that can be added to inventory depth based on the standardization assumptions described in Chapter IV. It is in two parts. The first shows the potential inventory increases resulting from savings achieved by reduction of duplicate parts currently in the system. It also provides the inventory increases that result from savings realized by standardizing parts entering the Navy Supply System in 1987. The second part continues the latter assessment for 1988 and 1989.

Potential Inventory Increase

Nomenclature	Cost/ Part	Inventory Range	Dup Parts Funds Avail	Dup Addnl Parts/Range	1987 Annual Funds Avail	Total 1987 Funds Avail	1987 Addnl Parts/Range
PUMPS	527	31,450	604,037	0.030	409,614	4,480,481	0.222
BOILERS	190	4,653	101,957	0.095	50,796	442,521	0.411
HEAT EXCHANGERS	856	3,350	68,817	0.020	27,758	286,996	0.082
CONDENSERS	944	1,793	40,505	0.020	11,349	72,580	0.035
TURBINES	1,098	25,566	579,753	0.017	200,458	1,370,578	0.040
COMPRESSORS	238	15,554	309,270	0.069	238,629	2,535,772	0.564
HEATERS	208	3,154	60,681	0.076	43,333	568,639	0.712
DISTILLING PLANTS	964	1,280	36,028	0.024	20,427	121,112	0.081
BATTERY CHANGERS	223	1,088	23,188	0.079	21,087	217,039	0.738
METERS	888	329	8,276	0.023	5,140	52,313	0.147
CONVERTERS	359	3,778	78,010	0.047	51,780	509,996	0.309
TRANSFORMERS	388	220	4,463	0.043	740	12,440	0.120
CIRCUIT BREAKERS	28	9,928	188,732	0.567	74,410	881,684	2.647
CONTROLLERS	31	47,248	897,610	0.506	698,397	7,769,785	4.382
GENERATORS	4,429	2,992	114,016	0.007	119,881	810,167	0.050
MOTORS	687	17,518	335,263	0.023	245,244	3,235,752	0.221
MOTOR GENERATORS	2,114	1,053	39,267	0.015	24,613	101,428	0.037
RELAYS	43	1,929	36,789	0.368	14,507	192,056	1.923
RHEOSTATS	131	636	12,581	0.124	1,983	21,531	0.212
SWITCHES	101	9,260	176,153	0.155	90,387	1,265,543	1.116
SWITCHBOARDS	481	10,646	207,655	0.033	59,650	628,413	0.101
VISUAL ALARMS	82	923	17,890	0.196	5,714	70,063	0.767
LIGHTING FIXTURES	23	1,294	24,656	0.682	9,486	126,061	3.485
GYRO COMPASSES	154	7,657	149,860	0.104	42,049	423,880	0.295
PROJECTION EQUIP	0	1,040	19,740	0.000	7,318	85,768	0.000
I/C EQUIP	152	5,144	99,529	0.105	38,253	409,650	0.432
NAVIGATIONAL EQUIP	9	3,623	69,111	1.674	84,559	942,885	22.835
INJECTORS	60	462	9,943	0.297	5,037	46,707	1.395
BURNERS	399	981	29,540	0.062	19,915	120,993	0.254
MARINE HARDWARE	172	3,146	60,787	0.092	16,874	196,423	0.299
REFRIG EQUIP	953	8,518	168,984	0.017	224,208	2,589,888	0.263
AIR CONDITIONING	265	670	15,329	0.071	19,335	198,836	0.923
STARTERS	263	1,620	36,761	0.071	26,773	244,970	0.473
WIPERS	4	623	11,877	3.600	4,202	48,463	14.688
AUDIBLE ALARMS	586	248	9,150	0.052	9,396	68,377	0.388
BEARINGS	2,921	790	26,098	0.009	14,559	69,063	0.025
INDICATORS	132	5,480	105,066	0.120	80,643	947,836	1.080
CLUTCHES	1,555	694	35,616	0.027	29,966	128,510	0.098
FANS	1,195	1,146	23,577	0.014	10,917	165,018	0.099
SHOP EQUIP	156	6,416	122,785	0.101	86,589	1,049,879	0.865
REGULATORS	65	3,978	76,430	0.243	21,367	228,859	0.729
GALLEY EQUIP	495	6,962	137,091	0.033	135,437	1,516,107	0.362
DEHYDRATORS	748	1,359	38,298	0.031	26,648	180,498	0.146
GAGES	261	4,065	78,184	0.061	33,143	430,759	0.335
TESTING EQUIP	141	2,548	50,105	0.114	55,539	603,178	1.378
FILTERS	190	8,908	170,598	0.083	99,390	1,165,911	0.566
PANELS	159	12,795	244,425	0.099	134,417	1,549,489	0.627

Potentiol Inventory Increose

Nomencloture	Cost/ Part	Inventory Ronge	Dup Ports Funds Avail	Dup Addnl Parts/Ronge	1987 Annuol Funds Avail	Totol 1987 Funds Avail	1987 Addnl Parts/Range
ISOLATORS	691	35	4,339	Ø.148	3,674	8,126	Ø.276
HYDRALIC EQUIP	1,379	7,866	173,47Ø	Ø.Ø13	248,345	2,496,349	Ø.189
CAPSTANS	1,816	525	3Ø,661	Ø.Ø26	24,995	91,162	Ø.Ø79
REELS	175	995	2Ø,61Ø	Ø.Ø98	22,474	243,531	1.154
DAVITS	2,ØØ9	334	17,Ø32	Ø.Ø21	12,Ø7Ø	39,442	Ø.Ø48
CRANES	2,264	2,763	114,399	Ø.Ø15	81,519	341,1Ø3	Ø.Ø45
HOISTS	138	3,4Ø6	66,662	Ø.117	34,883	367,172	Ø.644
ELEVATORS	243	4,81Ø	96,135	Ø.Ø68	2Ø,227	184,647	Ø.13Ø
STEERING EQUIP	Ø	1,881	35,72Ø	Ø.ØØØ	14,Ø98	158,9Ø1	Ø.ØØØ
CONTROL EQUIP	75	22,Ø51	419,489	Ø.2Ø9	218,74Ø	2,516,436	1.256
WINCHES	1,Ø74	4,823	112,8Ø6	Ø.Ø18	95,874	886,249	Ø.141
WINDLASSES	588	1,418	42,564	Ø.Ø42	22,571	1Ø8,723	Ø.1Ø7
FIREFIGHTING EQUIP	14Ø	1,639	33,141	Ø.119	58,414	626,111	2.244
LUBRICATORS	111	633	12,854	Ø.151	7,769	84,644	Ø.992
ENGINES	144	55,154	1,Ø95,2Ø7	Ø.113	953,678	1Ø,171,638	1.Ø51
PLUMBING EQUIP	Ø	583	11,Ø66	Ø.ØØØ	4,452	54,323	Ø.ØØØ
GEARS AND REDUCERS	1,3Ø1	9,78Ø	214,378	Ø.Ø14	1ØØ,379	861,581	Ø.Ø56
GOVERNORS	152	6,729	135,743	Ø.1Ø9	186,746	1,996,976	1.6Ø3
IGNITION EQUIP	125	23	2,625	Ø.75Ø	2,188	5,155	1.472
EJECTORS	644	1,556	36,886	Ø.Ø3Ø	11,Ø43	57,683	Ø.Ø47
EDUCTORS	1,342	185	5,543	Ø.Ø18	2,632	15,316	Ø.Ø51
STRAINERS	31	3,143	59,76Ø	Ø.51Ø	15,949	242,875	2.Ø73
PURIFIERS	192	6,275	132,886	Ø.Ø91	134,631	1,375,529	Ø.938
TRAPS-STEAM	79	1,Ø14	19,494	Ø.2Ø1	3,ØØ9	4Ø,131	Ø.415
COUPLINGS	3,644	942	28,96Ø	Ø.ØØ7	26,517	239,68Ø	Ø.Ø57
SILENCING EQUIP	227	121	2,811	Ø.Ø84	1,557	17,644	Ø.529
BRAKES	288	1,242	24,899	Ø.Ø57	13,482	159,527	Ø.367
BLOWERS	165	2,94Ø	61,954	Ø.1Ø5	27,939	255,489	Ø.435
WELDING SYSTEMS	Ø	1,743	33,1Ø4	Ø.ØØØ	35,715	394,262	Ø.ØØØ
BOAT PROPULSION	5,786	1,591	6Ø,979	Ø.ØØ5	39,774	174,727	Ø.Ø16
DECK MACHINERY	32Ø	4,573	89,52Ø	Ø.Ø5Ø	28,793	312,627	Ø.176
PHOTOGRAPHIC EQUIP	Ø	216	4,1Ø2	Ø.ØØØ	1,781	21,482	Ø.ØØØ
UNDERWATER LOG EQUIP	2Ø6	1,553	34,168	Ø.Ø88	7,655	43,323	Ø.112
VALVES	3Ø	88,881	1,687,977	Ø.521	584,243	7,494,861	2.312
MISC PARTS	16	38,368	729,371	Ø.991	719,424	8,ØØØ,22Ø	1Ø.87Ø
LAUNDRY EQUIP	197	3,927	78,757	Ø.Ø84	34Ø,948	3,791,Ø28	4.Ø38
TANKS	7,5Ø6	955	46,648	Ø.ØØ5	34,2Ø1	133,527	Ø.Ø15
PIPE, HOSE, & FITTINGS	1,47Ø	139	7,1Ø5	Ø.Ø29	5,257	2Ø,817	Ø.Ø84
ASW EQUIP	2Ø6	91Ø	25,436	Ø.111	33,878	3Ø1,958	1.322
YELLOW GEAR	Ø	4,468	84,837	Ø.ØØØ	597,Ø67	7,Ø85,754	Ø.ØØØ
PERISCOPES	235	2,978	62,453	Ø.Ø73	15,691	121,364	Ø.143
MISC EQUIP	35	2,986	56,883	Ø.442	18,541	23Ø,293	1.791
GRAND TOTALS	736	58Ø,657	11,767,913		8,464,941	9Ø,957,281	
Ave Depth Inc			Ø.Ø23		Ø.Ø16	Ø.175	
Ave # Ports			13,154		9,462	1Ø1,672	

Nomenclature	1988 Annual Funds Avail	Total 1988 Funds Avail	1988 Addnl Parts/Range	1989 Annual Funds Avail	Total 1989 Funds Avail	1989 Addnl Parts/Range
PUMPS	430,095	4,704,506	0.222	451,600	4,939,731	0.222
BOILERS	53,336	464,647	0.411	56,003	487,880	0.411
HEAT EXCHANGERS	29,146	303,470	0.083	30,603	321,000	0.084
CONDENSERS	11,916	76,618	0.035	12,512	80,904	0.036
TURBINES	210,481	1,439,107	0.040	221,005	1,511,063	0.040
COMPRESSORS	250,561	2,662,561	0.564	263,089	2,795,689	0.564
HEATERS	45,500	603,482	0.719	47,775	640,766	0.728
DISTILLING PLANTS	21,449	127,168	0.081	22,521	133,526	0.081
BATTERY CHANGERS	22,141	228,823	0.741	23,248	241,298	0.744
METERS	5,397	55,711	0.149	5,667	59,365	0.152
CONVERTERS	54,369	535,495	0.309	57,088	562,270	0.309
TRANSFORMERS	777	13,398	0.123	816	14,440	0.127
CIRCUIT BREAKERS	78,131	931,359	2.663	82,037	984,127	2.680
CONTROLLERS	804,687	8,952,557	4.809	977,506	10,875,717	5.563
GENERATORS	117,940	762,692	0.045	168,877	1,300,202	0.073
MOTORS	257,506	3,434,103	0.224	270,381	3,646,356	0.226
MOTOR GENERATORS	25,843	106,835	0.038	27,136	112,548	0.038
RELAYS	15,233	203,821	1.944	15,994	216,409	1.965
RHEOSTATS	2,082	22,831	0.214	2,186	24,221	0.216
SWITCHES	103,217	1,463,903	1.229	123,815	1,779,916	1.424
SWITCHBOARDS	62,632	662,554	0.101	65,764	698,699	0.102
VISUAL ALARMS	6,000	74,237	0.774	6,300	78,692	0.781
LIGHTING FIXTURES	9,960	133,781	3.523	10,458	142,040	3.562
GYRO COMPASSES	44,151	445,074	0.295	46,359	467,327	0.295
PROJECTION EQUIP	7,999	90,057	0.000	8,399	94,559	0.000
I/C EQUIP	40,166	430,132	0.432	42,174	451,639	0.432
NAVIGATIONAL EQUIP	99,851	1,113,673	25.686	125,395	1,399,049	30.732
INJECTORS	5,289	49,042	1.395	5,554	51,495	1.395
BURNERS	20,805	127,043	0.254	21,846	133,395	0.254
MARINE HARDWARE	17,718	207,735	0.301	18,604	219,775	0.303
REFRIG EQUIP	254,757	2,966,594	0.286	303,419	3,566,188	0.328
AIR CONDITIONING	20,301	209,747	0.927	21,317	221,309	0.932
STARTERS	28,112	257,218	0.473	29,517	270,079	0.473
WIPERS	4,412	51,110	14.753	4,632	53,914	14.821
AUDIBLE ALARMS	9,866	72,168	0.390	10,359	76,190	0.392
BEARINGS	15,287	73,038	0.025	16,051	77,269	0.025
INDICATORS	84,675	1,001,228	1.086	88,909	1,057,944	1.093
CLUTCHES	31,464	134,936	0.098	33,037	141,683	0.098
FANS	11,463	176,698	0.101	12,036	189,335	0.103
SHOP EQUIP	81,767	997,708	0.783	130,703	1,612,280	1.205
REGULATORS	22,436	240,302	0.729	23,558	252,317	0.729
GALLEY EQUIP	142,208	1,599,478	0.363	149,319	1,687,843	0.365
DEHYDRATORS	27,981	189,523	0.146	29,380	198,999	0.146
GAGES	34,801	457,142	0.338	36,541	485,373	0.342
TESTING EQUIP	58,315	633,337	1.378	61,231	665,003	1.378
FILTERS	104,360	1,231,586	0.569	109,578	1,301,350	0.573
PANELS	141,138	1,635,312	0.630	148,195	1,726,336	0.633

Potential Inventory Increase

Nomenclature	1988 Annual Funds Avail	Total 1988 Funds Avail	1988 Addnl Parts/Range	1989 Annual Funds Avail	Total 1989 Funds Avail	1989 Addnl Parts/Range
ISOLATORS	3,858	8,533	0.276	4,050	8,959	0.276
HYDRALIC EQUIP	290,540	2,946,147	0.213	360,385	3,697,170	0.254
CAPSTANS	25,974	92,835	0.076	29,384	121,950	0.095
REELS	25,743	281,767	1.271	31,015	343,730	1.477
DAVITS	12,674	41,563	0.048	13,307	43,807	0.049
CRANES	85,595	358,159	0.045	89,875	376,067	0.045
HOISTS	36,627	385,531	0.644	38,458	404,807	0.644
ELEVATORS	21,239	193,879	0.130	22,301	203,573	0.130
STEERING EQUIP	14,303	166,346	0.000	15,543	175,188	0.000
CONTROL EQUIP	229,676	2,654,892	1.262	241,160	2,801,649	1.268
WINCHES	109,420	1,029,386	0.156	131,148	1,264,442	0.182
WINDLASSES	23,700	114,159	0.107	24,885	119,867	0.107
FIREFIGHTING EQUIP	61,335	657,417	2.244	64,401	690,288	2.244
LUBRICATORS	8,157	89,398	0.998	8,565	94,446	1.004
ENGINES	1,001,362	10,680,220	1.051	1,051,430	11,214,231	1.051
PLUMBING EQUIP	4,675	57,411	0.000	4,908	60,695	0.000
GEARS AND REDUCERS	105,398	904,660	0.056	110,668	949,893	0.056
GOVERNORS	218,161	2,341,397	1.789	270,083	2,912,805	2.120
IGNITION EQUIP	2,297	5,412	1.472	2,412	5,683	1.472
EJECTORS	11,595	60,753	0.048	12,175	63,998	0.048
EDUCTORS	2,854	17,933	0.057	3,164	22,201	0.067
STRAINERS	16,746	259,007	2.105	17,584	276,380	2.140
PURIFIERS	141,363	1,444,305	0.938	148,431	1,516,521	0.938
TRAPS-STEAM	3,159	42,659	0.420	3,317	45,371	0.425
COUPLINGS	29,636	280,060	0.064	34,449	345,623	0.075
SILENCING EQUIP	1,635	18,787	0.536	1,717	20,016	0.544
BRAKES	14,157	169,031	0.370	14,864	179,177	0.374
BLOWERS	29,336	268,264	0.435	30,803	281,677	0.435
WELDING SYSTEMS	37,501	413,975	0.000	39,376	434,674	0.000
BOAT PROPULSION	41,762	184,432	0.016	43,850	194,729	0.016
DECK MACHINERY	30,232	330,048	0.177	31,744	348,534	0.178
PHOTOGRAPHIC EQUIP	1,870	22,667	0.000	1,963	23,925	0.000
UNDERWATER LOG EQUIP	8,037	45,489	0.112	8,439	47,763	0.112
VALVES	613,455	7,942,954	2.334	644,128	8,421,447	2.357
MISC PARTS	755,395	8,400,231	10.870	793,165	8,820,243	10.870
LAUNDRY EQUIP	402,518	4,480,568	4.545	505,353	5,633,421	5.443
TANKS	35,912	141,061	0.015	37,707	149,065	0.016
PIPE, HOSE, & FITTINGS	5,520	22,007	0.084	5,796	23,272	0.085
ASW EQUIP	35,572	317,056	1.322	37,351	332,909	1.322
YELLOW GEAR	626,920	7,485,028	0.000	658,266	7,909,169	0.000
PERISCOPES	16,476	127,433	0.143	17,300	133,804	0.143
MISC EQUIP	19,468	243,783	1.806	20,441	258,163	1.821
GRAND TOTALS	9,090,070	98,080,683		10,043,855	109,018,840	
Ave Depth Inc	0.017	0.180		0.018	0.190	
Ave # Parts	9,677	104,414		10,183	110,532	

APPENDIX K : TECHNICAL DATA MODEL[123]

NSLC developed an approach to objectively determine the value, to the government, of purchasing technical data. The following model provides a method for economically assessing the feasibility of acquiring data.

System Life (SL). System life, as the name implies, is the equipment's life expectancy. Part life (PL) is the part's equivalence to SL.

Replacement Rate (R). The replacement rate is the ratio of system life (SL) expectancy to part life expectancy (PL). The formula is:

$$R = (SL)/(PL)$$

Population . (POP). The population includes all installed and replacement quantities, and is a function of the Replacement Rate (R) and Life Expectancy (L). Therefore:

$$POP = f(R, L)$$

Interest Rate (IR). Interest Rate is the standard government planning figure of 10%, therefore:

$$IR = 0.10$$

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[123] Unless other noted, this section was taken from Mr. Richard Jones' paper, H,M&E Standardization.

Unit Price (UP). The price per item is a function of the time value of money with the current price and interest rate (IR) as the baseline. The function is:

$$UP = f(IR)$$

Savings from Competition (SC). DAR Supplement 6 states that the government realizes a 25% savings from competition, so:

$$SC = 0.25$$

Obsolescence (O). Obsolescence is a factor that ranges from 0.0 to 1.0, and is developed from the following formula:

$$O = \frac{\text{Number of Years for Part Obsolescence}}{SL}$$

The default value = 1.0.

Testing and Tools (T). Testing and tools are the variable dollar costs for the total investment for special test equipment, tools, and other related costs.

Technological State of the Art (SA). This element is a measure of sensitivity to the stability to the industry. It directly reflects the technological currency of the equipment and ranges between 0.0 and 1.0. When there are fewer suppliers for outdated equipment, there is a greater stability risk, and the value will be closer to zero. As SA is related to the number of manufacturers within the industry (B), it can be measured as:

$$SA = 1 - 1/B$$

The default value is set to 1.0 since procurements are assumed to reflect current technology and are therefore low risk.

Potential for Commercial Applications (CA). CA reflects equipment applications within the civilian sector. Assigned a value between 0.0 and 1.0, a number close to 0 indicates that the equipment is common and readily available. The lower the percentage, the higher the potential for competition. The value of data ownership decreases with commonalty. CA is assumed to be inversely related to the number of APL's (Z) (i.e. substitutability). The formula is:

$$CA = 1/Z.$$

Model Formulation. Since the model computes the savings accrued through data ownership, the number of parts purchased following delivery of technical data must be computed. Part population over the lifetime, (POP_P), equals the added parts installed following initial procurement, (POP_A), and the replacement parts purchased to support all installed equipment, (POP_R). It is assumed that following initial deliveries, procurements will be competitive and therefore the need to include POP_A. The formula is:

$$POP_P = POP_A + POP_R$$

POP_A is computed from the formula:

$$POP_A = \sum_{y=i}^{n} X_y$$

where y denotes succeeding years, and
X_y is the quantity that will be added to the population each year.

POP_R is computed as:

$$POP_R = [\sum_{y=0}^{n} X_{i+y}](R)$$

where i denotes initial (as in initial procurement), and
X_{i+y} includes all equipment, both initial procurements and follow-ons.

Since part life (PL) is the reciprocal of the part replacement rate, or:

$$PL = 1/R$$

Since 1/R equals Best Replacement Factor (BRF), then BRF is substituted in the equation for PL.

POP_R can then be restated as:

$$POP_R = [\sum_{y=0}^{n} X_{i+y}](BRF)(SL)$$

The price of the part in any year following first deliveries (P_y) is a function of the initial Unit Price (UP_i) and the interest rate (IR). The price for the part then becomes:

$$P_y = UP_i(1 + IR)^y$$

With this background, the formula for computing the potential savings is:

$$[\sum_{y=1}^{n} X_y + \sum_{y=0}^{n} X_{i+y}(BRF)(SL)][UP_i(1 + IR)^y](.25)(O)(1-1/B)(1/Z)-T$$

If the price of the technical data package is less than the savings computed from the formula, then it is cost-effective to purchase the data rights.

The same formula can also be used as follows, to compute the value for a piece of equipment since it is really the sum of its m component parts:

$$\sum^{m}\{[\sum_{y=1}^{n} X_y + \sum_{y=0}^{n} X_{i+y}(BRF)(SL)][UP_i(1 + IR)^y]\}(.25)(O)(1-1/B)(1/Z)-\sum^{m} T.$$

The only difference between the two formulas is that the latter uses $\{[\sum_{y=1}^{n} X_y + \sum_{y=0}^{n} X_{i+y}(BRF)(SL)][UP_i(1 + IR)^y]\}$ to compute the sum of the parts before applying the remainder of the equation.

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